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Adaptation to climate change and water sensitive city development.

Enhancing resilience and transforming cities through nature as infrastructure.

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Research summary

The increasing impacts of climate change, urban demographic growth and migrations are pressures that exacerbate the vulnerability of cities. In order to respond and enhance their resilience, cities implement adaptation strategies that involve the transformation of the urban space. This requires an approach to the development and design of the urban territory that takes into account the new conditions, thus questioning the modern and post-modern principles and practices.

While engaging in the path towards adaptation goals and successive stages of sustainability in the context of water-related climate impacts, the relationship between cities and 'nature' within their own borders is forcedly changed as well as the physical space.

Adaptation, due to its systemic nature, is multi-scalar: at the macro level – urban scale, it is implemented through plans and strategies (adaptation process); at the meso/micro level - urban and architectural design scale, these strategies are realized through concrete interventions (adaptation projects). In the case of climatic extremes related to water, more and more often we are witnessing the use of the so-called 'nature' as infrastructure resulting from an eco-centric and holistic approach, rather than the use of the traditional techno-centric approach. Through the analysis of the transformation process at the macro level via a multi-level perspective approach and implemented or planned interventions as blue/green and traditional grey infrastructure projects in selected cities, the research aims to investigate the relationship between cities and 'nature' and the urban space produced by the projects aimed at adaptation goals. The cities of Miami and Rotterdam subjected to considerable water-related impacts to are taken as a sample to analyse two different urban transformation pathways towards adaptation.

Although the sample cases constitute only a partial view on the topic, the analysis is useful for drawing some conclusions and highlighting the factors that support the process of urban adaptation and those that constitute a brake, providing some hints and approaches transferable to other urban areas. The transformative approach, a multidisciplinary and systemic vision of the challenges the city faces, the integration of the development of water management policies in urban planning as well as the consistency in the adaptive orientation at the various levels so that strategic planning finds concrete implementation through tangible interventions, are elements that allow to tackle the impacts and allow to consider that the need for adaptation to climate change may represent an opportunity for cities to enhance resilience and modify urban space with benefits in terms of the liveability of the urban space itself.

0 Introduction

A large part of the world's population lives in urbanised coastal zones or river deltas (UN Habitat, 2013). There is growing recognition that the increasing vulnerability of coastal cities to climate change impacts is strongly related to urbanisation, demographic growth, changing socio-economic conditions, migrations, human-related impacts such as building in prone areas or human-induced land subsidence. As the world urbanizes, cities contribute and at the same time are victims of climate change (Grimm et al. 2008); they play a key role in addressing global environmental concerns and problems, and cities' transition to sustainability is becoming crucial (Geels 2011). To handle the threats they are facing, they are necessarily engaged in improving their own resistance, and increasingly they are taking the path to adapt to climate change with a view to enhance resilience.

"Whatever the warming scenarios, and however successful mitigation efforts prove to be, the impact of climate change will increase in the coming decades because of the delayed impacts of past and current greenhouse gas emissions. We therefore have no choice but to take adaptation measures to deal with the unavoidable climate impacts and their economic, environmental and social costs. By prioritising coherent, flexible and participatory approaches, it is cheaper to take early, planned adaptation action than to pay the price of not adapting." (EU COM 2013/0216).

Some cities have adopted detailed adaptation strategies or specific action plans (e.g. on the prevention of risks, floods or water management) or are developing them, others have already implemented the interventions provided for in the strategic plans and have achieved more advanced goals in terms of sustainability and resilience.
Among all environmental systems, water is one in which climate change is manifest in a more dramatic and effective manner. Urban water management is therefore one of the main elements of the transition path towards an enhanced resilience.

0.1 Planning and design for urban adaptation

Years ago, Bernardo Secchi highlighted *"Conditions have changed: designing today means tackling problems, using methods, and expressing different intentions from a recent past"* [1] (Secchi 1984, p.8). Twenty-first-century urbanization must necessarily confront a risk scenario linked to the impact of increasing human activity in a complex relationship with nature. As noted by Secchi and Viganò, reflecting on the landscape of the 21st century means confronting the challenge of uncertainty (the awareness of uncertainty) and this must mobilize our collective knowledge and our imaginative skills (Secchi and Viganò in Fabian and Viganò 2010).
The emergence of the environmental question and the awareness of the limit of resources have led to reflections that challenge modern and post-modern principles and practices, thus "to rethink the ways and forms of urban development" (Cavalieri in Fabian and Viganò 2010, p. 98).
Adaptation requires a transformation that involves all aspects of the structure (physical and otherwise) of urban life. Transitions to sustainability are complex, long-term processes that include multiple actors and necessarily require an interdisciplinary approach, involving interactions between technology, politics/power/policy, economics/business/markets and culture/public opinion often called *socio-technical transitions* (Geels 2001).
"Adaptation, appropriation, and flexibility are now the hallmarks of 'successful' systems, as it is through their ability to respond to contextual and environmental conditions that they persist" (Reed in Waldheim 2006, p.280). In this perspective, adaptation appears as a necessary development forced by the need of cities to maintain their balance and their operation.

1. Bernardo Secchi, Le condizioni sono cambiate, in "Casabella: Architettura come modificazione", n.498/9, Electa Periodici, Jan.- Feb. 1984, p.8. Translation by the author.

From an evolutionary point of view, John McNeil highlights two dominant development strategies:

- the ***shark strategy*** consisting of "supreme adaptation to existing circumstances" and pursuing specialization. It works efficiently, but only if the circumstances are stable.
- the ***rat strategy*** considered the best long-term survival strategy in biological evolution, which consists of being adaptable, looking for different sources of subsistence and maximizing resilience (McNeill 2002).

The attitude of the great shark of the 20th century, hungry for resources and capable of modifying environmental conditions according to its own needs, determined the establishment of a highly specialized civilization based on the use of fossil fuels and produced a "permanent ecological disorder" (McNeill 2002) which introduced us into the Anthropocene era.

0.2 Water and urban adaptation

The process of transformation towards adaptation leads to the generation of products/projects that, in the management of urban water resources, take the form of infrastructures aimed at deadening or responding to impacts. Infrastructure is designed to meet a request and provide a specific performance to respond to and address a given problem or need. The most techno-centric philosophy of the conventional approach typical of recent history, which involves the use of technical solutions, has often addressed urban water management (and not) through traditional systems or **grey infrastructure** (GI) with numerous environmental and economic consequences. GIs are designed for a function and respond to a performance. Like the shark, the GIs often guarantee good functionality in stable conditions, but turn out to be inadequate to face the climatic extremes. Moreover, in Western countries, often designed and built decades ago, the GIs have problems of obsolescence and difficult maintenance.
The integration of planning, design, engineering disciplines, landscape design in the project of urban water are supported as new approaches towards urban space (e.g. Novotny at al. 2014, Wong and Brown 2009).
In the case of climatic extremes related to water, more and more often we are witnessing the use of nature as infrastructure. An alternative approach, holistic and eco-centric, proposes a harmonization between functioning, function, performance and spatial planning in urban areas. In the contemporary debate in urban planning and in the field of water management, there is a growing interest in maximizing the benefits of using nature as an infrastructure involv-

ing the use of **blue/green infrastructure** (BGI). Nature is therefore called and used to respond to a performance. As Hung stated

"Infrastructure, as we know it, no longer belongs in the exclusive realm of engineers and transportation planners. In the context of our rapidly changing cities and towns, infrastructure is experiencing a paradigm shift where multiple-use programming and the integration of latent ecologies is a primary consideration. Defining contemporary infrastructure requires a multi- disciplinary team of landscape architects, engineers, architects and planners to fully realize the benefits to our cultural and natural systems." (Hung 2011 p.15).

Architects and urban planners play a key role in addressing new approaches and strategies aimed at adaptation goals.

The use of BGI and strategies intended to protect and/or restore ecosystem services are increasingly interested in and applied to the sustainable management of urban water resources. To address the sustainability challenges facing cities, Grove emphasizes that the development of solutions will require "approaches that perceive cities as complex, dynamic and adaptive systems that depend on interconnected ecosystem services at the local, regional and global scale" (Grove 2009, p. 293).

From the point of view of water management, Novotny identifies four existing historically recognizable models or paradigms that reflect the evolution of the relationship between the city and its water resources (Novotny and Brown 2014). Novotny argues that a new model or 5th paradigm of sustainable and resilient water resource management emerges and is increasingly accepted and supported, adopting a holistic rather than a functionalist approach (Novotny and Brown 2014). This new approach in water management, can be more generally referred to a new approach in the production of urban space.

0.3 Objective

The research is above all a reflection on the theme of the water emergency in the contemporary city and on the renewed paradigms that arise from this global challenge. It aims to identify operational intervention models and design actions to address the problem of water in urban contexts and transform it into a resource for the contemporary city.

While engaging in the path towards adaptation objectives and successive stages of sustainability in the context of water-related climate impacts, the relationship between cities and nature within their own borders is forcibly changed. Focusing on adaptation to water-related impacts, through the analysis of the transformation process and implemented and planned blue/green and traditional grey infrastructure projects, the research aims to investigate the relationship between cities and nature and the urban space produced by the projects aimed ad adaptation goals.

It is the goal of the research to find out how this relationship is changed and consequently how the urban space is modified by the adaptation processes that produces projects that use nature as infrastructure and traditional grey infrastructure.

0.4 Approach and methods

Adaptation, due to its systemic nature, is multi-scalar: at the macro level, i.e. at the scale of the strategic planning that often involves the whole urban area, it's implemented through the creation of plans, programs and strategies aimed at capturing the elements of greatest vulnerability and risk, and defining the main lines and the intervention policies that the urban area wants to pursue to implement the complex transformations necessary to achieve sustainability objectives; at the meso and micro level, i.e. at the scale of scale of the interventions, these adaptation policies and strategies are implemented through concrete projects.

In order to investigate how the transformation processes and the infrastructure projects (BGI, GI and hybrid) aimed at adaptation goals contribute to the generation of new ways and forms of urban space, the research is carried out on two different scales with different methods but aimed at achieving closely connected results.

At first instance the process of transition will be examined at a macro level - scale of the strategic planning. In order to analyse the process through which complex urban transformations occur in the management of impacts linked to water, an approach that takes many aspects into consideration is necessary. The Multi-level perspective approach (MLP) for socio-technical transitions is then used to compare the urban transition processes of the selected cities.

Secondly, the research focuses on a meso/micro level - scale of physical interventions aimed at adaptation and proposes the study of GBI, GI and hybrid infrastructure projects implemented in the selected cities, in order to analyse the production of the space that these projects have operated and their relationship with 'nature'.

Data are collected from open sources, including the case cities' official websites, published plans, documents, articles and reports, participation at public meetings and presentations. Moreover, historical maps, plans, pictures and documents are collected so as to clarify the historical relationship of the city with water resources and impacts and the the current path towards adaptation goals. In order to validate and collect updated and more in-depth data an online questionnaire is conducted with relevant city managers and experts of the selected cities. Questionnaires are followed by emails when clarification is needed, and semi-structured interviews are performed. A city profile, interventions mapping andselection, and projects sheets describe the case cities at the macro and at the meso/micro level.

Macro level - Scale of the strategic planning - Adaptation process: transformation process towards sustainability goals

At the city's scale, the analysis aims to investigate the process of urban transformation towards an enhanced sustainability. The transition process involves technical and social aspects of the city and implicates systemic changes often called *"socio-technical transition"* (Geels 2011). The MLP approach can be relevant to understand the transition process of the urban water management system towards a more sustainable condition (Geels, 2011; Geels & Schot, 2007; Liu & Jensen 2017) and is a means to explain how technological transitions occur and understand the interaction of actors, environments and innovations. In order to analyse the development of urban water transition and urban scale benchmarking analysis the research proposes to apply the conceptual tool urban water transitions framework presented by Brown R. R. (Brown et al. 2009; Wong et al. 2009; Liu et al. 2017) which presents a typology of different states that cities go through when pursuing change towards more sustainable futures. The research proposes to apply the MLP approach in order to investigate the socio-technical transition of the selected cities and define their transition state in relation to the urban water transitions framework towards water sensitive cities. Thus, a city profile describes the main features related to the adaptation process and the urban water management of each research case.

Meso/micro level - scale of the interventions - Adaptation projects

As far as the analysis at the scale of interventions is concerned, a general framework has been defined which contains the categories useful for the description of implemented or planned projects and is connected to the two dominant development strategies according the aforementioned evolutionary point of view: the shark and the rat.
A first definition of the projects is based on the analysis of the adaptation approach that the projects themselves implement, distinguishing three broad

categories:
- *coping approach* focused on solving the problem rather than addressing complex issues, thus handling with the emergency with a relatively quick and not extremely expensive solution;
- *incremental adaptation* when existing adaptation measures are incrementally improved and increased in efficiency and implemented in order to follow the requirements of vulnerability assessment and adaptation plans;
- *transformational adaptation* that promotes a change of approach towards the challenges, trying to provide new and innovative solutions with the aim of transforming problems in opportunities and support the path to a resilient and sustainable city. Transformational adaptation is a wider and systemic approach that investigates and deals with the causes, frequently linked to human actions, e.g. settlements set in risk-prone areas, inadequate building design or other human activities that may increase the impact of climate change. (EEA 2016)

A second feature of the projects concerns the type of infrastructure implemented distinguishing
- the techno-centric approach typical of *grey infrastructure* (shark);
- the eco-centric holistic approach of *blue-green infrastructure* (rat);
- the *hybrid approach* (projects using both blue-green and grey infrastructure).

A further classification defines the projects based on the spatial relationship the project establishes with water and on the action towards water. The four main features are:
- *in - absorb/contain;*
- *out - reject/repel;*
- *on - float;*
- *above - suspend.*

A fifth feature corresponds to *away - retreat /relocate* away from the territory where the impacts are more intense, although this feature is not highly represented in the analysis so far implemented.
Each of the previous feature has 3 sub-categories that describe the approach or action of the project with the status prior to execution: *reuse/retrofit, add and remove/subtract.*
A further analysis of the projects refers to some qualitative elements that define the *social, economic, environmental, ecological, and communication values* with respect to the condition prior to the intervention. Furthermore, considerations on the *advantages, disadvantages* and the established *relationship with water* are added. The mentioned features are used as a framework to analyse implemented or planned adaptation projects in the selected cities. A more detailed description is provided also through the examples of project analysis

sheets where the projects are presented also through graphic elaborations, in addition to the previously mentioned descriptors.

0.5 Research cases selection

The research proposes to analyse cities that historically have a significant and privileged relationship with water and the sea. Two cities that are part of the '100 Resilient Cities Program' (100RC) network, a non-profit organization set up by the Rockefeller Foundation with the mission of helping cities around the world to respond adequately to the economic, social and physical challenges of the 21st century, are chosen as research cases. The urban areas of Miami and Rotterdam have been selected, on the one hand because of their relationship with water and the sea, sometimes problematic to the point that, for different reasons, they are faced with continuous emergencies linked to the management of water resources, on the other because both are found in the list of the first fifteen cities in terms of resources exposed to coastal floods in the time horizon of 2070 (Nicholls et al. 2007). Another relevant element for the selection of cities was the availability of data and the possibility of spending research periods on the spot, at the Florida International University (FIU) and at the Delft University of Technology (TU Delft).
The research cases represent a different geographic distribution as well as a difference in water management problems, thus constituting a range of possibility of intervention and management that can provide useful descriptive, explanatory and predictive indications of diagnosis and analysis to assess which strategic action initiatives adapt better to the current conditions of the urban system.
At the scale of the strategic planning (macro level), through an analysis of open source documents, the historical relationship with water, adaptation plans and resilience strategies, implemented and planned measures, questionnaires and interviews, it is proposed to define a profile of the case studies cities examined. The result allows to define the transition status of each case study towards sustainable water management in urban areas and of which practices, policies and strategies have contributed to the achievement of the reached stage. At the same time a mapping of adaptation interventions (meso/micro level) is carried out; some GI, BGI and hybrid projects are selected and an analysis of the projects, of the process from which they originated and of the space they generated is conduct.

0.6 Scope

Starting from the analysis of the selected cases, the research is an occasion for reflection, albeit partial and provisional, on the ways in which environmental emergencies, deriving from climate change, are answered in a renewed project of urban space. The research approaches the project in a different way than it is usually approached in practice and aims to suggest a contribution to the integration between the disciplines that deal with urban space (architecture, urban design, landscape architecture, urban planning, civil engineering), and decision-makers in the common purpose of designing adaptive cities.
The analysis of the adaptation process at the macro level – scale of the strategic planning strategies, and of adaptation projects at the meso/micro level - scale of the interventions result in a critical comparison of the processes that generated GI, BGI and hybrid interventions, and the spaces produced by the projects themselves. The results may contribute to the debate on the generation of new ways and forms of urban space through the use of nature as an infrastructure and more in general of the changed relationship between the cities and nature.
The comparison between the analyses carried out on the research cases through the MLP approach will also allow to identify the stage of the transition framework towards water sensitive cities in which they are located, and to evaluate which processes, strategies, best practices have been put in place and which elements of acceleration of the process towards sustainable water management in urban areas can be disseminated and adapted in other urban areas. The research can therefore provide elements that identify critical issues in the current management of urban waters and suggest the steps that can improve the process towards an enhanced resilience.

0.7 Outline and structure

The thesis is structured around three sections for a total of three chapters plus an introduction and a final part. The introduction summarizes the essential thesis themes, developed and elaborated in the following chapters, providing a general overview of the main subject, the methods and approaches adopted, the selection of research cases and the research scope.
Chapter 1 addresses the urgency of climate change and water related impacts on the contemporary urban environment. It focuses on the need for urban adaptation and the related approaches and is aimed at providing an indication of some keywords used in the context. Moreover, it provides a reflection on the contemporary cities and how design and planning need to take into account

the current challenges posed by climatic, demographic, social and economic impacts and consequently propose new practices then those of the modern and post-modern.
Chapter 2 outlines the adaptation path and the transition process cities need to go through and describes the method of analysis structured on two different scales. At the macro level - scale of the strategic planning - the Multi-level perspective approach and the Urban Water Management Transition Framework are presented in order to investigate the adaptation process and the consequent urban transformation towards sustainability goals. At the meso/micro level - scale of the interventions - some categories are thematised with the aim critically describing adaptation projects. Moreover, data collection methods are described.
Chapter 3 is dedicated to the selection of the research case cities. The analysis on the urban areas of Miami and Rotterdam at the macro and meso/micro level are then presented. City profiles, interventions mapping, and selected projects sheets draw a picture of the two cities that enable to present a comparison in the latter part of the chapter.
The conclusions offer an overview of the central themes and observations that emerged from the research. General principles that establish the cultural and operational paths towards sustainable urban water management practices are identified. Moreover, conclusions provide a reflection on core elements that, in fruitful cases, have enabled and contributed to speed progress in the urban adaptation process and enhance urban resilience.

1 Problem definition

1.1 Climate change and urban impacts

The threat and fear of tragic unexpected events and apocalyptic cataclysms impacting communities and cities in a dramatic and unpredictable way has always accompanied the history of human beings and religions (Fig. 1, 2). Beyond superstitions, in recent years we have witnessed an intensification of environmental phenomena of unusual extent due to the ongoing climate changes, with catastrophic repercussions on urban areas and more generally on human activity, subject to an ever-increasing vulnerability.

The bar graph in Fig. 3 shows how the number of lossy events has increased significantly from 1980 to 2017, and how the highest percentage of losses is due to hydro-geological and weather events. The annual research *"Global Risks 2019: Insight Report"* shows how environmental risks dominate the Global Risks Perception Survey with three of the top five risks by likelihood and four by impact (Fig.4). Extreme weather in 2019 is the risk of greatest concern, and the failure of climate-change mitigation and adaptation is number two in terms of impact (Fig.5).

"The results of climate inaction are becoming increasingly clear. The accelerating pace of biodiversity loss is a particular concern. Species abundance is down by 60% since 1970. In the human food chain, biodiversity loss is affecting health and socioeconomic development, with implications for well-being, productivity, and even regional security" (Weltwirtschaftsforum, and Zurich Insurance Group 2019 page 5).

Fig.1. Thomas Cole, The Course of Empire Consummation 1835-36
Source: http://www.the-athenaeum.org/art/full.php?ID=8535

Throughout its long history, Earth has warmed and cooled time and again. Global warming is the unusually rapid increase in Earth's average surface temperature. When the planet received more or less sunlight due to subtle modifications in its orbit, when the atmosphere or surface has changed or when the energy of the Sun has variated, climate on Earth has changed. Temperature is one of the most immediate and obvious effects of global warming.
According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2014), global warming since the mid-20th century is primarily a consequence of greenhouse gas emissions due to human activities (IPCC 2014). The global average surface temperature rose 0.6 to 0.9 degrees Celsius (1.1 to 1.6° F) between 1906 and 2005, and the rate of temperature increase has nearly doubled in the last 50 years. Moreover, temperatures are certain to go up further[1]. The average global temperature has increased by about 0.8 degrees Celsius over the past 100 years, according to the IPCC report (AR5) and it will increase from 1.5 to 5 degrees Celsius, depending on RC Pathways, in 2100.

1. Riebeek, H. (2010). Features. Retrieved from Earth observatory: http://earthobservatory.nasa.gov/Features/GlobalWarming/

Fig.2. Thomas Cole, The Course of Empire Destruction 1836
Source: https://commons.wikimedia.org/w/index.php?curid=183045

As temperature rise, hurricanes and other storms are likely to become stronger. Ice is melting worldwide, and less fresh water will be available. One of the most dramatic effects of global warming is the reduction in Arctic sea ice: according to NASA, the polar ice caps are melting at an alarming rate of 9% per decade. The thickness of the Arctic Ice has decreased by 40% since the 1960s. According to scientists at the U.S Center for Atmospheric Research, if the current rate of global temperature rise continues, the Arctic will be free of Ice by 2040. In September 2013 the National Geographic published maps representing what the world would look like if all the ice melted: if global warming will eventually melt all the ice at the poles and on mountaintops, the sea level would raise by 216 feet (65.83 m). The maps in fig. 6 and 7 show the new coastline in Europe and North America according a scenario where all the ice on land has melted and drained into the sea.

However, even though strong mitigation actions are put into practice to maintain climate change impacts under a threshold that still allows the main services to function reasonably well, even if global greenhouse gas emissions would end nowadays, climate would continue to change as a consequence of emissions of the last decades and the inertia of the climate system, and the

Fig. 3 . Munich Re. "TOPICS GEO - Natural Catastrophes 2016. Analyses, Assessments, Positions. 2017 Issue." Munich Re - Münchener Rückversicherungs-Gesellschaft, 2017.

sea level would continue to rise. Mitigation by itself is not able to avoid the impacts of climate change. Thus, in order to face the adverse impacts of climate change, mitigation and adaptation actions should be brought about in a harmonized approach.

Cities are home to more than a half of the world's population and produce nearly the 80 percent of the world GDP [2] (Brears 2018). A large part of the world's population lives in urbanised coastal zones or river deltas (UN Habitat, 2013). UN Habitat reports estimates that 550 million people will live in coastal cities in 2050 (UN-Habitat 2016). According to data from the National Oceanic and Atmospheric Administration, US government agency, about 100 million people live at an altitude between 0 and 180 cm from the average sea level (NOAA 2017). It has been estimated that 23% of the world's population lives both within 100 km distance of the coast and <100 m above sea level; population densities in coastal regions are about three times higher than the global average, and a growing population will be exposed to the impacts of sea level rise (Neumann et al. 2015). We are witnessing a strong global trend of migration towards coastal mega cities, in particular in Asia there's an exceptional tendency to coastward migration in recent decades. This trend is expected to endure in the coming years (UN Habitat, 2013).

There is growing recognition that the increasing vulnerability of coastal cities to climate change impacts is strongly related to urbanisation, demographic growth, changing socio-economic conditions, migrations, human-related impacts such as building in prone areas or human-induced land subsidence.

2. Gross domestic product (GDP) is a monetary measure of the market value of all the final goods and services produced in a specific time period.

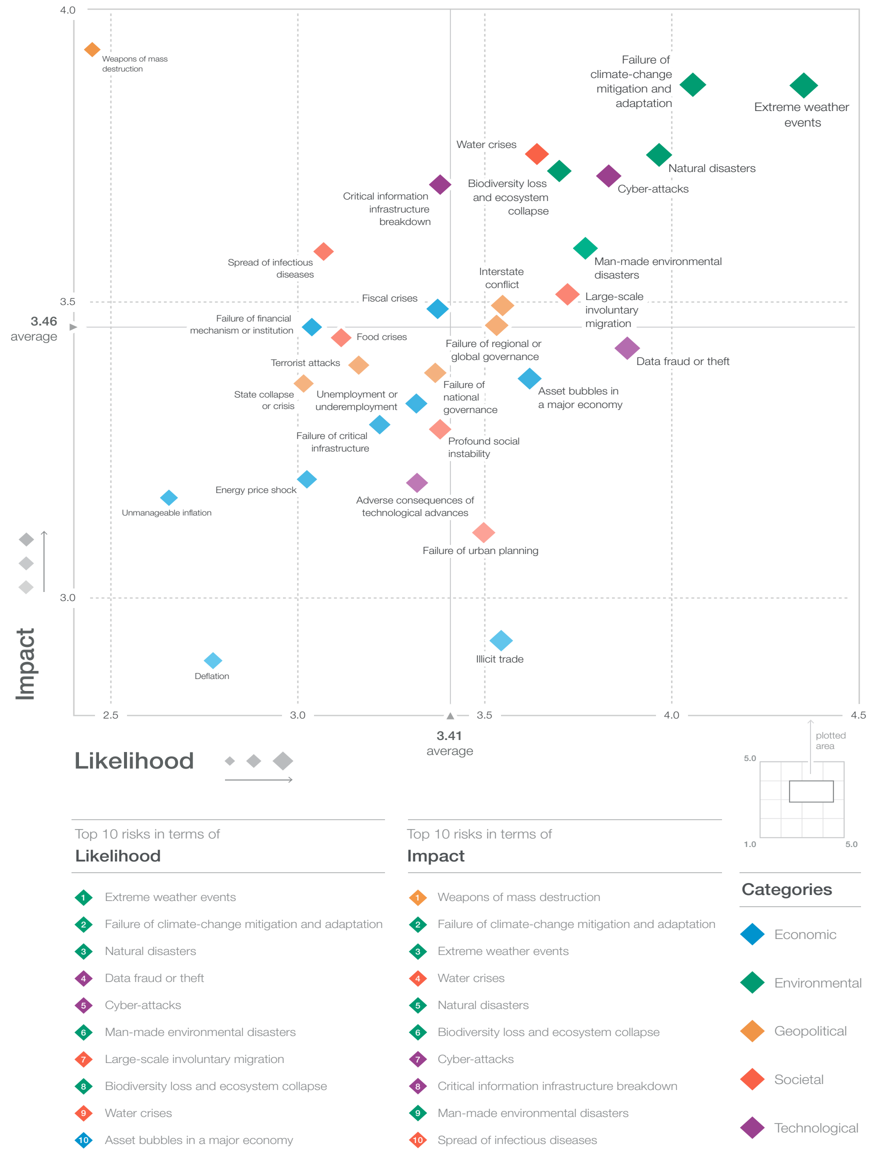


Fig. 4. The Global Risks Landscape 2019 - The Global Risks Report 2019
Source: Weltwirtschaftsforum, and Zurich Insurance Group. Global Risks 2019: Insight Report, 2019

The impacts of climate variability are found in the dramatic urban disasters that reveal too often the weakness of the contemporary city, the causes of which are to be found in the unrestrained consumption of land, in the alteration of natural dynamics, in widespread and chaotic urbanization, in illegal building and/or informal construction, in infrastructure obsolescence.
Strictly connected to the process of urbanisation, human induced changes of the natural landscape are increasingly recognised as main source of rising risk.

Fig. 5. The Global Risks Interconnections Map 2019- The Global Risks Report 2019
Source: Weltwirtschaftsforum, and Zurich Insurance Group. Global Risks 2019: Insight Report, 2019

In particular, coastal and deltas cities experience an increasing risk of flooding due to land subsidence, often as a result of excessive ground water withdrawal. This is specifically a general problem for younger Asian mega cities such as Bangkok, Jakarta and Metro Manila where the rate of subsidence in some cases locally surpasses the maximum projected rates for sea level rise (Nicholls et al. 2007). The process of subsidence is often due to drainage of marshlands. and settling (land compaction) due to urbanisation.

Fig. 6, 7. National Geographic coastline ice melt. What the World Would Look Like if All the Ice Melted. The maps here show Europe and North America as they are now, with only one difference: all the ice on land has melted and drained into the sea, raising it 216 feet and creating new shorelines for our continents and inland seas. This story appears in the September 2013 issue of National Geographic magazine. Source: https://www.nationalgeographic.com/magazine/2013/09/rising-seas-ice-melt-new-shoreline-maps/

1.2 Does climate change require new design and planning approaches?

As Bernardo Secchi mentioned years ago "*Conditions have changed: designing today means tackling problems, using methods, and expressing different intentions from a recent past"* (Secchi 1984 page 8).
Twenty-first-century urbanization must necessarily confront a risk scenario linked to the impact of increasing human activity in a complex relationship with nature.
Climate change (CC) gives rise to a proliferation of discourses and approaches in the disciplines of the project - architecture, urban planning, landscape. Several scholars highlight the questioning of the principles and practices of modern and post-modern, suggest new approaches to the territory and prefigure and witness the creation of new paradigms.

The physical transformation linked to the climate in the world has a great scientific consensus, built and presented also through the IPCC. However, according to Mike Hulme in *Why we disagree about Climate Change*, the transformation goes far beyond the physical one observed, predicted and "modelled" by the IPCC and other scientists: the idea of climate change carries within it a series of meanings.
"We need new ways of looking at the phenomenon of climate change – an idea circulating and mutating through our social worlds – and new ways of making sense of the many different meanings attached to the idea of climate change"
(Hulme 2009 page 12).
Rather than catalysing disagreements about how, when and where to deal with CC, we must tackle the idea of CC as an imaginative resource around which our collective and personal identities and projects can and should take shape. According to the Anthropocene thesis, humanity is an active agent in shaping the climate in the world. Hulme claims that in order to try to understand the CC we must understand and observe the ways in which its meaning is narrated. He argues that CC is altering not only our physical world, but also our social world and believes that the idea of CC can lead to a new ethical and theological thought on our relationship with the future, arouse new interest in how science and culture intertwine and stimulate new social movements to explore new ways of living in urban and rural contexts.
"Whereas a modernist reading may once have regarded climate as merely a physical boundary condition for human action, we must now recognise climate change as an overlying, fluid and imaginative condition of human existence" (ibidem).

Fig.8. Flooded Modernity, Havsteen-Mikkelsen. Floating Art Festival, Vejle Fjord, Vejle Museum-Denmark.

Etienne Turpin in *Architecture in the Anthropocene* states that the concept of Anthropocene offers contemporary scholars, activists and designers a unique opportunity to re-evaluate the terms of theory and practice that have been inherited from modernity. Among these legacies, the assumption of an ontological distinction between human culture and nature is lost, appearing as an erroneously presumed fact. Another legacy that is reconsidered is the climate of the earth system, no longer thought of as a fact, but as the result of the co-production of human and non-human forces that generate (meteorological) weather. The predictability of weather, seasons and known models has allowed the development of agriculture and practices necessary for human survival. The destabilization of these models - climate change - causes exposure to extreme weather conditions and the consequent risk, especially for those economically and geographically more vulnerable communities. Whatever the answer to this exasperated vulnerability - greater hostility, conflict and violence, or more radical forms of political solidarity and mutual aid - our reaction to climate change is and will be written in the Anthropocene geological archive (Turpin 2013).
According to the latter rhetoric, adaptation and more generally the effects of climate change do not foresee adaptation in a pragmatic way but propose

an imaginative effort that foreshadows new social economic perspectives and new ways of life.

The indiscriminate use of resources and the effects that this has caused have generated systemic impacts that translate into significant social, economic and environmental costs that are extremely unpredictable in terms of location, nature and scale thus, we face risks that we had not taken into account in our decision-making processes.

"The 20th century was not designed, nor planned, it was engineered. It was a period of heightened urban need where fresh water sources required separation from waste effluents, where energy resources were required and inventoried to achieve economies of scale as well as to light up the extended work day, where highways had to be constructed to short circuit the distance between farm and market, with the rise of logistical cold chains, amidst patterns of increasing daily mobility"
(Belangér 2013 page 54).

Climate change made us aware in practical terms of our physical connections and interdependencies with nature. These consciousness "are changing both the context and the nature of spatial planning at all levels" (Davoudi et al. 2009 page 7), fosters deep professional, technical, theoretical and ethical issues for planners and designers shaping the sustainable development debate and "further strengthening the critiques of dominant development pathways and raising interest in alternative development policy responses at different scales and in different places. It advocates searching for new opportunities, new tools and new rationales" (ibidem).

As noted by Secchi and Viganò, reflecting on the landscape of the 21st century means confronting the challenge of uncertainty (the awareness of uncertainty) and this must mobilize our collective knowledge and our imaginative skills (Secchi e Viganò in Fabian et al. 2010). The emergence of the environmental question and the awareness of the limit of resources have led to reflections that challenge modern and post-modern principles and practices, thus "to rethink the ways and forms of urban development" (Cavalieri in Fabian et al. 2010 page 98).

Recent years reflection has produced a serious critical analysis of recent history and of the technical cultures that have formed and consolidated, fostering a specialized knowledge. This led to "the creation of new paradigms that on the one hand recuperate the pre modern wisdom for which the 'new science' started out, but that on the other hand still have great difficulty in staking a place for themselves" (Secchi in Fabian et al. 2010 page33).

Pelling argues that a priority for human development is to learn how to live with CC impacts, thus adaptation cannot be seen as a mere defensive task that displays in protecting core assets or functions from the risks of CC, but rather a more profound engagement, in which CC risks are seen as a product and driver of social as well as natural systems, and their interaction (Pelling 2011).

The research is above all a reflection on urban adaptation, on the theme of the water emergency in the contemporary city and on the renewed approaches that arise from this global challenge. It aims to identify operational intervention models and design actions to address the problem of water in urban contexts and transform it into a resource for the contemporary city. Focusing on adaptation to water-related impacts, through the analysis of the transformation processes and implemented and planned projects, the research aims to investigate the relationship between cities and nature and the urban space produced by the projects aimed at adaptation goals.

1.3 Urban Adaptation

Cities are centres of production, consumption, and waste disposal that lead land change and generate global environmental problems; urban centres, particularly those in the developed world, are the main source of greenhouse-gas emissions and thus are implicated in global climate change (Grimm et al. 2008). As the world urbanizes, cities contribute and at the same time are victims of climate change (Grimm et al. 2008). Taking this into account, they play a key role in addressing global environmental concerns and problems, and cities' transition to sustainability is becoming crucial (Geels 2011). To handle the threats they are facing, they are necessarily engaged in improving their own resistance, and increasingly they are taking the path to adapt to climate change with a view to enhance resilience.

"Whatever the warming scenarios, and however successful mitigation efforts prove to be, the impact of climate change will increase in the coming decades because of the delayed impacts of past and current greenhouse gas emissions. We therefore have no choice but to take adaptation measures to deal with the unavoidable climate impacts and their economic, environmental and social costs. By prioritising coherent, flexible and participatory approaches, it is cheaper to take early, planned adaptation action than to pay the price of not adapting."
(COM/2013/0216 page 2).

Cities have always been struggling to tackle the problems of unforeseen climatic events that sometimes may change the existing balance and urban structure in a tragic and irreparable way. Urban areas mostly reacted to past catastrophic events, such as flooding, droughts or heat waves, trying to adapt in order to escape the disasters in the future. The unexpected event most commonly became a part of water, health or disaster risk management and

the measures taken are a starting point, even if few cities followed the path towards adapting to future climate changes.
The European Union (EU), through its reports and funding programs, has been supporting climate change urban mitigation adaptation actions. The EU set up an Adaptation Strategy developed in the Covenant of Mayors for Climate and Energy, an adaptation initiative. Moreover, the Paris climate conference (COP21) defined an action plan for adaptation in December 2015. Furthermore, the UN Sustainable Development Goals underline the necessity for cities to take action. Climate change is a systemic challenge that is strictly linked to socio-economic dynamics and regional and global aspects and tendencies.
Some cities have adopted detailed adaptation strategies or specific action plans (e.g. on the prevention of risks, floods or water management) or are developing them, others have already implemented the interventions provided for in the strategic plans and have achieved more advanced goals in terms of sustainability and resilience. Few cities well along in the process are already implementing adaptation actions and fostering monitoring and reporting measures. However, some cities may lack the skills and organizational capability to adapt and combine climate resilience with additional sustainability targets (Liu and Jensen 2017).

1.4 Adaptation, mitigation, resilience

Adaptation is one of the key terms to which the more general concept of 'resilience' refers. In fact, it means the reactivity, adaptability and dynamic stability of a system which, in the case of urban areas subject to anthropogenic and climatic impacts, needs to reduce their vulnerability through 'adaptive strategies'. Adaptation is defined by the IPCC as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities' (IPCC, 2007c, p869). Mitigation is defined as 'anthropogenic [human] intervention to reduce the sources or enhance the sinks of greenhouse gases' (ibidem). While mitigation measures aim to avoid the adverse impacts of climate change in the long term, adaptation measures are designed to reduce unavoidable impacts of climate change in the short and medium terms (Davoudi et al. 2009). As an integral part of sustainable development, mitigation of, and adaption to, climate change are closely linked and both have the same purpose: reducing undesirable consequences of climate change (ibidem).
Resilience is the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to, and recover from the effects of a hazard promptly and efficiently by preserving and restoring essential basic structures

(UNISDR 2011b). The Rockefeller Foundation - 100 Resilient cities adopted the following definition of urban resilience: the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience. A resilient community is one that can absorb disturbances, change, reorganize, and still retain the same basic structures and provide the same services (Resilience Alliance 2002). As a concept, resilience can be applied to any community and any type of disturbance: natural, man-made, or a combination of the two. Disaster resilience can be seen as a public good that builds an appropriate amount of redundancy into urban systems and encourages communities to plan how to deal with disruptions (Jha 2013). Adaptation, mitigation and resilience are now everyday terms in the practice of design and urban policies. The debate on the definition of these terms has produced numerous useful contributions that have helped to analyze many aspects.

1.5 Planning and design for urban adaptation

"There is widespread recognition that the spatial configuration of cities and towns and the ways in which land is used and developed have significant implications for both adaptation to the adverse impacts of climate change and reduction of the emissions that are causing the change" (Davoudi et al. 2009 page13).
As Christiano Lepratti argues, referring to evolutionary biology, the evolution of the form of architecture and of cities happens also through mechanisms of adaptation to nature and, now more than ever, to its changes (Lepratti 2018). Adaptation requires a transformation that involves all aspects of the structure (physical and otherwise) of urban life. Transitions to sustainability are complex, long-term processes that include multiple actors and necessarily require an interdisciplinary approach, involving interactions between technology, politics/power/policy, economics/business/markets and culture/public opinion often called *socio-technical transitions* (Geels 2001).
"Adaptation, appropriation, and flexibility are now the hallmarks of 'successful' systems, as it is through their ability to respond to contextual and environmental conditions that they persist" (Reed in Waldheim 2006, p.280).
In this perspective, adaptation appears as a necessary development forced by the need of cities to maintain their balance and their operation.
The confrontation with climate change and with the impacts that cities face, as mentioned in the previous paragraphs, question the consolidated idea of the relationship between man and 'nature' and consequently, in the disciplines that deal with project, the relationship between city, the territory and the natural environment.
To address the sustainability challenges facing cities, Grove emphasizes that

the development of solutions will require *"approaches that perceive cities as complex, dynamic and adaptive systems that depend on interconnected ecosystem services at the local, regional and global scale"* (Grove 2009, page 293).
The city we are aiming for is therefore an elastic, metamorphic, changeable city, no longer foreign to the dynamics of the environment in which it is inserted, but capable of changing and evolving together with it, thus capable of co-evolving. A new idea of the city, which inevitably underlies an unprecedented vision of urban ecology: an adaptive city that is able to digest the mutational environment scenario and is sensitive to change, making those project themes.
Perceived from an ecological point of view, a city is its own fully functioning ecosystem. An ecosystem is defined as a biological community of living organisms in conjunction with the non-living components of their physical environment, interacting as a system. These biotic and abiotic components are linked together through nutrient cycles and energy flows. This concept can be applied to urban areas. The main difference between an urban ecosystem and our traditional understanding of ecosystems is that the physical environment in cities has human-made as well as natural elements that are affected not only by the natural environment but also by culture, personal behaviour, politics, economics, and social organization. The urban ecosystem thus contains both individual and nested systems from three spheres: the natural, the built, and the socioeconomic environments (Jha 2013). Thus, in order to deal with the impacts of CC, a systemic approach is required.
Ecosystem services are defined as "the benefits people obtain from ecosystems. These include provisioning services such as food, water, timber, and fibre; regulating services that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling" (Millennium Ecosystem Assessment, 2005). Ecosystem-based approaches to adaptation refer to "the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change as part of an overall adaptation strategy." (Convention on Biological Diversity, 2009)
While planning and designing for an adaptable city, the conventional approaches are put into question and a different relationship between the city and nature is to be pursued. "
Landscape in the West was itself a symptom of modern loss, a cultural form that emerged only after humanity's primal relationship to nature had been disrupted by urbanism, commerce and technology" (Christopher Wood, 1993).

Evolutionary development strategies: the shark and the rat

The evolution of the species on Earth has generated strategies for development and adaptation to external circumstances. John McNeil in Something New Under the Sun warns about the alterations in the evolutionary paths of the human species during the past century. From an evolutionary point of view, he highlights two dominant development strategies: the shark and the rat strategies.

- the ***shark strategy*** consisting of "supreme adaptation to existing circumstances" and pursuing specialization. It works efficiently, but only if the circumstances are stable.

A shark has fins and a streamlined body that help it swim through water. It has gills, which take in oxygen directly out of the water. Because of its gills, sharks can stay underwater and not have to come to the surface to breathe. Sharks also have a tremendous number of sharp teeth, which make them fierce predators. Sharks are an apex predator, which means that they are at the top of their food chains: no one (except humans) can hunt most sharks.
However, sharks are swimming in oceans that are becoming warmer and more acidic, forcing them to adapt to their new environment and to migrate where water temperatures are more in line with their needs. Moreover, the changing conditions will also impact the oceans and their rich habitat for the larger species of fish. A rapidly changing climate may put sharks at risk, because their slow rate of evolution makes them slow to respond to acute climate change.

- the ***rat strategy*** is considered the best long-term survival strategy in biological evolution, consists of being adaptable, looking for different sources of subsistence and maximizing resilience (McNeill 2002).

The homo sapiens, as some species of rat, has survived to shocks that killed competitors and has proven biological success on adaptability. However, a parallel can be made between human and the above-mentioned dominant development strategies, putting into question the human 'development' of the recent past.
The attitude of the great shark of the 20th century, hungry for resources and capable of modifying environmental conditions according to its own needs, determined the establishment of a highly specialized civilization based on the use of fossil fuels and produced a "permanent ecological disorder" (McNeill 2002) which introduced us into the Anthropocene era.

Adaptation approaches

In the European Union, the commitment to adaptation is carried out at various levels through directives, communications, reports, networks and funded projects that aim to pool the experiences, actions and solutions already implemented in some cities. The need of adaptation plans for European cities is clearly stated in the report *"Urban adaptation to climate change in Europe 2016"* (EEA 2016) that provides an overview of the measures and strategies that may be used in order for European cities to adapt to climate change, the improvements and advances already pursued in the latest years and the future challenges to be faced so to reach the goal of well-adapted and climate-resilient cities for a climate-resilient Europe. The report describes the path to adapt and convert cities into attractive, climate-resilient and sustainable places defining three main different approaches that city administrations can pursue towards adaptation depending on the circumstances, starting points and key actors involved.

Coping approach

Often planners and/or the decision-making bodies have to respond to an unforeseen tragic event and they put into practise existing adaptation measures and knowledge gained, for example in disaster risk management, coping with the emergency with a relatively quick and not extremely expensive solution, thus implementing a *coping approach* focused on solving the problem rather than addressing complex issues and interdependencies of climate change.

Incremental adaptation

When existing adaptation measures are incrementally improved and increased in efficiency and implemented in order to follow the requirements of vulnerability assessment and adaptation plans a second approach named *incremental adaptation* is set, thus following an approach based on opportunity. Incremental adaptation may be appropriate and efficient to cope with short and medium-term challenges.

However, coping and incremental adaptation implemented through "soft", "low-regret" and "low-cost" measures may be useful in a short term but may not be sufficient to respond in the long-term. As an example, the city of Vàc, near Budapest, needs to face severe flooding almost every four years as a result of the increasing impacts of climate change and the flood defences built in cities upstream, including in Slovakia, Austria and Germany which worsen

the flooding in Vàc. A plan to build a mobile dam to protect the city was set, however the dam is only 1 m higher than the 'last worst' flood and the flood level is increasing thus the problem will not be solved in long-term. As adaptation measures locally implemented can have considerable impacts on other places a regional perspective is essential to face the problem as well as a long-term perspective using future climate projections instead of relying on past experience in order to avoid subsequent events from producing damage over and over again, requiring costs that could otherwise be avoided.
Moreover, the coping approach and incremental adaptation are often only applied locally, while the impact of climate change may involve large areas also including different countries. An example is the Elbe river valley and the Dresden region where in the past years, several severe flooding events have caused huge damage to the region and the city. Dresden is only some 50 km away from the border with the Czech Republic; thus, the river and flood management across the border upstream is of immediate importance for Dresden. A regional and transnational approach to address flooding, involving Czech institutions in flood protection and forecasting helped Dresden to be much better prepared, to a large extent also because of the increased level of information and aided to face a severe flooding event in 2013 lowering the damage.

Transformational adaptation

Taking into account that extreme climate-driven events are foreseen to be more intense and recurrent a long-term vision should be aimed. In order to address the systemic challenge of climate change a third approach should be applied, described as *transformational adaptation* which is a wider and systemic approach that investigates and deals with the causes, frequently linked to human actions, e.g. settlements set in risk-prone areas, inadequate building design or other human activities that may increase the impact of climate change. Transformational adaptation promotes a change of approach towards the challenges, trying to provide new and innovative solutions with the aim of transforming problems in opportunities and support the path to a resilient and sustainable city. This approach is intended to combine adaptation with other aspects of urban development in a long-term systemic perspective, starting from the state of the art of the current city and trying to organise it in a different, more efficient and sustainable way. Transformational adaptation needs a longer time to be implemented and probably higher investments, on the other hand it considers the city in its many interwoven aspects, with the aim and vision of a better and more liveable city for the future.

Fig. 9. Amphibious houses in Maasbommel in the Netherlands
Source: www.urbangreenbluegrids.com

An example of a transformational approach related to SLR applied in Europe are the amphibious houses in Maasbommel in the Netherlands (see fig. 9). Much as 60 % of the country is below sea level, thus The Netherlands has a long history of mitigating flood damage and adapting to flood risk (EEA 2016). Some river floods in the '90s led to a more restrictive legislation and the implementation of a new government programme, Ruimte voor de Rivier (room for the river), in 1997. Under the new programme natural flood areas, which could store water temporarily if water levels rose were implemented with a substantial effect on urban developments as permanent buildings were not permitted in flood areas like Maasbommel. A project for houses based on floating foundations was brought about and in 2005 Maasbommel became the first site with amphibious houses. A new approach was pursued instead of the usual flood-resilient infrastructure and a change of attitude has been brought about with an attempt to live with different water levels instead of keeping the water out (Pötz 2014).

An adaptation plan or strategy often needs to combine a *coping approach* with *incremental adaptation* and *transformational adaptation* in order to face the climate change impacts and the specific local and regional conditions. Few cities already implemented adaptation plans combining the three adaptation approaches, however, cities like Copenhagen, Rotterdam, Bologna, the Em-

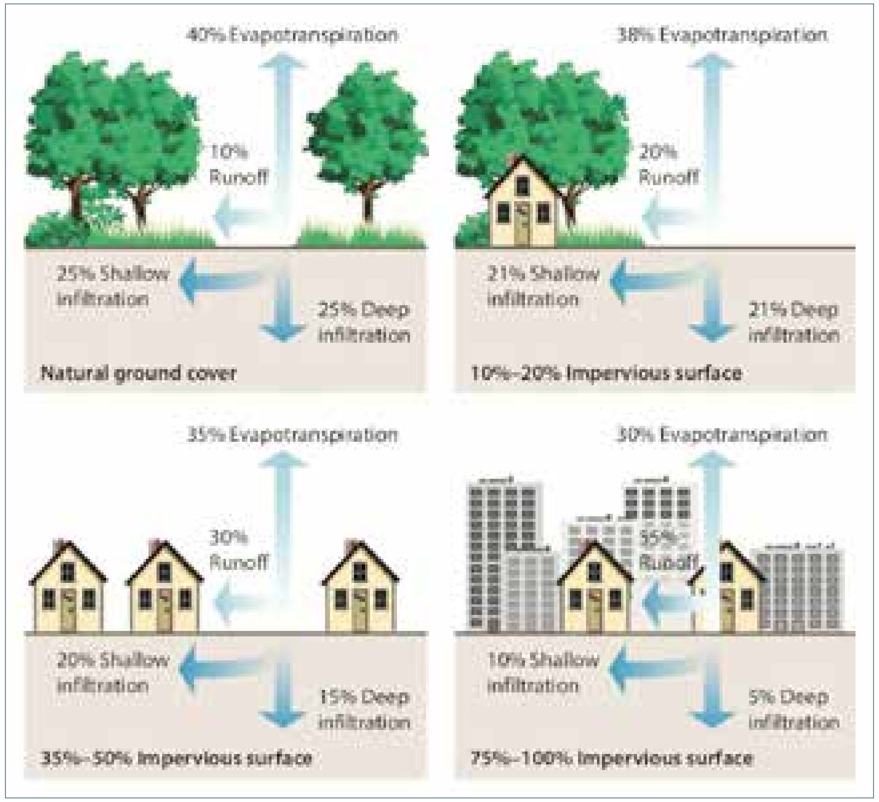


Fig.10. Change in watershed caracteristics after urbanisation. Source: Jha et al. 2013, World Bank.

scher valley in Germany, Bilbao in Spain, Eferdingen in Austria and some others, are engaged in transformative steps (EEA 2016).

Water in an urban environment

Extreme rainfall, floods, tidal waves, more and more intense storm surges, tsunamis, the continuous rise in sea levels, are the cause of widespread devastation in small villages, medium-sized towns, large cities, megacities and metropolitan areas. According to CC projections cities all over the world will experience threats to water supply security, heightened flood risks and severe heatwaves (Bates et al., 2008).
Among all environmental systems, water is one in which climate change is manifest in a more dramatic and effective manner. Urban water management is therefore one of the main elements of the transition path towards an enhanced resilience.
The spatial distribution of flood risk and water related impacts is a conse-

quence of the relationship between urbanisation and nature, as argued by several scholars. Land use patterns and land cover, and the extent and density of urbanization alter water processes, determine the probability of hydrogeological risks and consequent impacts (Kuzniecow Bacchin 2015). Fig. 10 represents an example of how the water process is modified by urbanization.
The increase in extreme water related climate events (IPCC 2014) and consequent impacts require a better understanding of the ever-evolving relationship between land and water. Interventions on the urban built environment in order to retrofit cities and make them adaptive and resilient requires a huge effort to define strategies able to manage water performance "along with additional ecological, spatial, and socio-economic values" (Kuzniecow Bacchin 2015 page 27).

Water management

According the Natural Resources Conservation Service - United States Department of Agriculture, water management is "the control and movement of water resources to minimize damage to life and property and to maximize efficient beneficial use". Water management can be defined as "the activity of planning, developing, distributing and optimum use of water resources under defined water polices and regulations. It includes management of water treatment of drinking water, industrial water, sewage or wastewater, management of water resources, of flood protection, of irrigation, and of the water table.
The EU Water Framework Directive (WFD) (EU, 2000) provides a solid legislative basis for long-term integrated water management in the EU. In 2012, the European Commission published A Blueprint to Safeguard Europe's Water Resources (COM (2012)673). It focuses on policy actions that will improve how current water legislation is applied in practice and on integrating water policy objectives with other policies. The Blueprint builds on water policies relating to water resource efficiency and sustainable water management in the same timeframe as the EU's 2020 Strategy up to 2050.

The main objective of water management in urban areas is to guarantee that periods of extreme rainfall either within or outside the city limits, storm surges and long periods of drought do not cause damages and problems in the city and in the surrounding environments (Potz 2016).

From the point of view of water management, Novotny identifies four existing historically recognizable models or paradigms that reflect the evolution of the relationship between the city and its water resources (Novotny 2014). Novotny argues that a new model or 5th paradigm of sustainable and resilient water resource management emerges and is increasingly accepted and supported, adopting a holistic rather than a functionalist approach (ibidem). This new approach in water management, can be more generally referred to a new approach in the production of urban space, as the new paradigms mentioned in the previous paragraphs. While engaging in the path towards adaptation objectives and successive stages of sustainability in the context of water-related climate impacts, the relationship between cities and nature within their own borders is forcibly changed.

Water sensitive urban design

Water Sensitive Urban Design (WSUD) is an approach that integrates urban water cycle management with urban planning and design, with the purpose of mimicking natural systems to minimise negative impacts on the natural water cycle and receiving waterways. It provides an alternative to the traditional management of storm water by minimising the volume of runoff from impervious surfaces and thereby reducing the required size of the structural storm water and waste water systems. It pursues to reduce impermeable surfaces, recycle water on site, include retention basins to diminish peak flows, and integrate treatment systems to eliminate pollutants (Melbourne Water 2016). WSUD main objectives are: protect or improve the environmental, social and economic standards of downstream environments; reduce the incidence, period and volume of storm water runoff to lessen the risks of flooding; improve attractiveness in the urban environment (Brears 2018). WSUD is one of the approaches towards a sustainable urban water management, as crucial part of the path towards adaptive and resilient cities and is being adopted especially in Australia. Through WSUD, cities aim to reach the development state of the water sensitive city that will be mentioned in chapter 2.

Fig.11. Stepwell “Chand Baori”, Abhaneri, Rajasthan, India. VII Century.

Infrastructures

The process of transformation towards adaptation leads to the generation of products/projects that, in the management of urban water resources, take the form of infrastructures aimed at deadening or responding to impacts. Infrastructure is designed to meet a request and provide a specific performance to respond to and address a given problem or need.
Infrastructure can be defined as the basic physical and organizational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society or enterprise, nonetheless it refers also to the social and economic infrastructure of a country, necessary to guarantee its existence and endurance. Human have always tried to supply essential needs, first of all water, through the construction of infrastructures, such as the Stepwell in fig. 11.

Technocentric approach - shark: grey infrastructure, function and performance

The most techno-centric philosophy of the conventional approach typical of recent history, which involves the use of technical solutions, has often addressed urban water management (and not) through traditional systems or ***grey infrastructure*** (GI) with numerous environmental and economic consequences. GIs are designed for a function and respond to a performance.
Like the shark, the GIs often guarantee good functionality in stable conditions, but are inadequate to face the climatic extremes. Moreover, in Western countries, often designed and built decades ago, the GIs have problems of obsolescence and difficult maintenance.
Water impacts and flood risks of in the last century have been tackled with an engineered, prevention-based flood risk management approach. Facing flooding through large-scale infrastructure such as dams and barriers is progressively considered as less appropriate due to increasing concerns over their negative ecological and socio-economic impacts, nonetheless because these solutions address the symptoms and not necessarily the root causes of increasing vulnerability (Pelling, 2011). There is a need to develop a resilience-based planning approach that addresses the root causes of urban vulnerability and deals with complex system behaviour.

Holistic and eco-centric approach – rat: blue-green infrastructure, multifunction, urban ecosystems

Simultaneously to the increasing water impacts and flood risk, there is a clear shift from a technocentric approach towards a more holistic, systemic approach (Pelling, 2011) and an increasing interest in integrated and multi-levelled approaches that are based on adapting existing urban environments. The integration of planning, design, engineering disciplines and landscape design in the project of urban water are supported as new approaches towards urban space (e.g. Novotny at al. 2014, Wong and Brown 2009). In the case of climatic extremes related to water, more and more often we are witnessing the use of ***nature as infrastructure***. An alternative approach, holistic and eco-centric, proposes a harmonization between functioning, function, performance and spatial planning in urban areas.

In the contemporary debate in urban planning and in the field of water management, there is a growing interest in maximizing the benefits of using nature as an infrastructure involving the use of ***blue/green infrastructure*** (BGI). Nature is therefore called and used to respond to a performance. The use of BGI and strategies aimed at protecting and/or restoring ecosystem services are increasingly interested in and applied to the sustainable management of urban water resources.

Green infrastructure is defined as “a strategically planned network of natural and semi- natural areas, incorporating green spaces, or blue if aquatic ecosystems are concerned, and other physical features” (European Commission 2013a). In the context of water, BGI is “a strategically planned network of high-quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity” (European Commission 2013b). As such, its purpose is to utilise natural processes to improve water quality and manage water quantity by restoring the hydrologic function of the urban landscape (Brears 2018). Infrastructure is no longer engineered for a single purpose. Natural elements within the city take on a new value, not only aesthetic and recreational, as it was framed in a recent past, but are intended as elements of a wider system, of the urban landscape (Donadieu 2008), and manage to fulfil some functions previously held only by the traditional infrastructure.

“Infrastructure, as we know it, no longer belongs in the exclusive realm of engineers and transportation planners. In the context of our rapidly changing cities and towns, infrastructure is experiencing a paradigm shift where multiple-use programming and the integration of latent ecologies is a primary consideration. Defining contemporary infrastructure requires a multidisciplinary team of landscape architects, engineers, architects and planners to fully realize the benefits to our cultural and natural systems”
(Hung et al in SWA Group 2011 page 16).

A multidisciplinary orientation is crucial, through using integrated design methods and tools to ensure greater involvement of the various stakeholders: public and private, clients, designers, builders, manufacturers and suppliers of materials throughout the entire supply chain.

1.10 The role of spatial design disciplines in urban adaptation

Architects, urban planners, designers and landscape architects play a key role in addressing new approaches and strategies aimed at adaptation goals. They are involved, in a broader sense on ‘critical thinking about space and place’ that concerns

“not only legislative and regulatory frameworks for the development and use of land, but also the institutional and social resources through which such frameworks are implemented, challenged and transformed […] It involves the processes through which options for the development of places are envisioned, assessed, negotiated, agreed and expressed in policy, regulatory and investment terms.”
(Davoudi et al. 2009 pag 13).

Often adaptation is still seen by decision makers as means to reduce risks, and not yet as an opportunity to produce a more liveable, attractive and socially just environment. Multidisciplinary and systemic approach appears essential to effectively address the path towards urban adaptation. Spatial design disciplines are involved in the diverse phases of the path, on different scales and have more than other stakeholders involved, the skills to offer a broad vision and enable cooperation and dialogue between practitioners who often adopt different ‘languages’ and different methods.

The responsibility of the disciplines of design, planning and landscape are crucial both in delivering the technical means to apply adaptation and mitigation policies, and in supporting and carrying forward negotiations over conflicting goals, bridging the gap between diverse voices with different power, develop synergies and thus finding inclusive and democratic place-based solutions.
The role of the design disciplines in the context of urban adaptation can be understood as place-based problem seeking and problem-solving aimed at sustainable development.

“A proliferation of governmental reports, national planning policy statements and emerging legislation at both national and international levels demonstrating a widespread recognition of the pivotal role of spatial planning [as well as the other disciplines that deal with the production of space] *in delivering climate change mitigation and adaptation policies”*
(Davoudi et al. 2009 pag 15).

2 Methodology

Adaptation paths towards sustainability and urban resilience, as mentioned, presume a transition that involves all physical and non-physical aspects of urban life. The research limits the analysis to the physical aspects proper to the discipline of architecture and urban planning and those who directly affect the physical space and, for example, omits the behavioural aspects related to the more or less sustainable habits of citizens.

Evaluating the tangible results of adaptive policy and actions is a challenge due to the anticipatory and ideally proactive characteristics of adaptation. Analyse, learn and obtain lessons from the experience of cities by examining the mechanisms that describe enhanced adaptation might be more useful. Thus, a method that focuses on the interdependency and dynamics of barriers[1] to, and drivers of adaptation is required (Eisenack et al., 2014).

Adaptation, due to its systemic nature, is multi-scalar: at the urban scale (macro level), it is implemented in the realization of plans, programs and strategies aimed at understanding the elements of greater vulnerability and risk, and at defining the main lines and policies intervention that the urban area itself wants to pursue to implement complex transformations required to achieve sustainability objectives; at the district-wide or single project scale,

1. Adaptation barriers can be defined as "obstacles that make adaptation less efficient, less effective or may require changes that lead to missed opportunities or higher costs" (Eisenack et al., 2014).

i.e. at the scale of the interventions (meso/micro level), these adaptation policies and strategies are implemented through concrete projects.
Cities transition to a more resilient stage involves the development of both the territorial scale, and the district-wide or single project scale. However, we can sometimes grasp a gap between the macro and meso/micro level, between strategy and implementation, between the image communicated by a city concerning its commitment towards sustainability and resilience, and the results in terms of projects aimed at adaptation. Plans and strategies often provide a partial and inaccurate vision of the real transformation path in progress in urban areas, of the actions and results achieved.
The analysis at the macro level alone can lead to think that the promoted efforts determine exemplary results, but to verify it, evidence at to the scale of the implemented interventions is necessary.
In order to investigate how the transformation processes and the projects (through infrastructures - BGI, GI and hybrid) aimed at adaptation goals contribute to the generation of new ways and forms of urban space, the analysis is carried out on two different scales with different methods but aimed at achieving closely connected results.
At first instance, the process of transition will be examined at a macro level - scale of the strategic planning. In order to analyse the process through which complex urban transformations occur in the management of impacts linked to water, an approach that takes many aspects into consideration is necessary. The *Multi-level perspective approach* (MLP) for socio-technical transitions is then used to compare the urban transition processes of the selected cities.
Secondly, the research focuses on a meso/micro level - scale of physical interventions aimed at adaptation, and proposes to identify features useful to study GBI, GI and hybrid infrastructure projects implemented in the selected cities, in order to analyse the production of space that these projects have operated and their relationship with 'nature'.

2.1 Macro level – scale of the strategic planning – analysis of the adaptation process

The need to adapt in order to deal with the pressures to which urban areas are subject to, leads to the generation of new visions for future cities that can simultaneously be resilient and help to mitigate the impacts. Future urban water systems play a key role in those visions focused on key concepts such as transitions, sustainability, liveability, resilience, productivity, prosperity,

adaptive capacity, integration and interdisciplinarity. Strategic planning is intended to provide the tools and guidance to achieve or at least aim at the desired vision. The macro level performs the job of leadership, awareness communication to citizenship, to other cities and to a wider public regarding local territorial policies, even assuming a role in the city branding: the sustainable and resilient city has indeed earned an aura of attractiveness and positivity, for example in tourism and political communication.
According to Ferguson, Brown and Deletic, there is a need for a reliable diagnostic procedure that can help planners, political analysts and decision makers in the selection and design of strategic action initiatives that best adapt to the current conditions of a water system to allow the desired system changes (Ferguson et al., 2013). Transitions scholars, regardless of their sectoral interests, have increasingly shown attention in urban water transition cases since urban water provides a comprehensive and representative context for exploring the dynamics of sustainability transitions (Haan et al. 2015), thus in-depth studies of urban water transition cases can be instrumental in the further advancement of the sustainability transitions field (ibidem). In the context of the water management sector, that has been considered as risk averse, technocratic and locked in (Brown et al., 2011), glimpses of progress can be seen in addressing the challenges of sustainability (see for example Brown et al., 2013).
Transition processes were analysed through different theoretical concepts, each one providing empirical, methodological and theoretical contributions useful to describe, depending on the specific focus, cases of urban water systems, geographical region, transition phase. Conceptual approaches as the *Transition Management*, the *Multi-Pattern Approach* and the *Social Network Theory* have been used to analyse the transition phases of pre-development and acceleration, focusing on urban stream health catchment management, flood management, recycled greywater and wastewater and harvested storm water as alternative supply source (Haan et al. 2015).
Other analytic frameworks for sustainability and transformative change applied to urban water systems are for example the *SES - Sustainability Framework* aimed at organising variables typologically to aid meta-analysis of case studies; *Ecosystem Stewardship Framework* whose purpose is to identify suites of strategies to support ecosystem stewardship; *Panarchy Framework* focused on analysing disturbances and adaptive capacity in dynamic systems; *Multi-Pattern Transition Framework* meant to analyse the dynamics of societal transitions (Ferguson et al. 2013, Cox 2011, Haan and Rotmans 2011, Folke 2006). In order to investigate socio-technical transition paths, Geels proposes to apply the *Multi-Level Perspective* approach (MLP) that describes transitions as results of alignments between multilevel de-

velopments (Geels et al. 2007). Among the various theoretical frameworks MLP is used to illustrate and organise case study results and interpretations (Haan et al. 2015).

Urban areas across different geographical characteristics and dimensions of water systems share common transition challenges (Haan et al. 2015) such as "the social and environmental vulnerabilities related to traditional approaches for managing rainfall and flood events; the need to diversify the water resources available to secure supplies in drought conditions; the changing economic climates and market liberalisation" (Ibidem page 7). Despite the specificity of each single urban area, comparing transition dynamics across multiple cases facing analogous challenges may be a base for theoretical generalisation (Haan et al. 2015). A comparison of the transition paths of different cases can thus be useful to understand the similar challenges, common patterns, how impacts and developments are tackled in order to be able to find out which practices, policies and strategies have contributed to the achievement of the accomplished sustainable stage.

A socio-technical perspective, like the MLP, can be helpful in understanding the transition process of the large urban water management system towards a more sustainable condition (Geels 2011, Geels & Schot 2007, Geels 2004). Moreover, among the mentioned theoretical concepts MLP is effective in order to compare the transition process of different cases, with different system dimensions, organizational, climatic and geographic structures.

At the macro level – scale of the strategic planning – adaptation process, the research proposes to apply the MLP approach to research cases in order to analyse the socio-technical transition of selected cities and define their transition state in relation to the urban water transitions framework towards water sensitive cities. The research conducted through the MLP provides valuable insights for the analysis at the meso/micro level and for the examination of physical and spatial aspects of the urban transition process.

2.1.1 Multi-level perspective approach for socio-technical transitions

Multilevel models of innovation were inspired by Rip and Kemp and were further developed by Frank Geels, among others (Rip and Kemp 1998). Generally, those models are "concerned with transformative change (system innovation), drawing on a co-evolutionary perspective, with technology and society mutually shaping each other, instead of one more or less determining the other" (Kemp 2010, page 292). MLP is defined as a middle-range theory (MRT) [2] that conceptualizes the general dynamic models in socio-technical transitions; it is a scheme that relates various concepts and uses empirical research to identify recurrent patterns and generalizable lessons (Geels 2011). The MLP approach is used to analyse transition paths in different fields (energy, transport, industrial transformations) and follows socio-technical (green) innovations (for example, fuel cell technology) from their inception to their adoption and application. In a socio-technical perspective, the MLP approach is relevant to understand the transition process of the urban water management system towards a more sustainable condition (Geels 2011, Geels & Schot 2007, Liu & Jensen 2017 and 2018) and is a means to explain how technological transitions occur and to understand the interaction of actors, environments and innovations. The MLP views transitions as non-linear processes that results from the interplay of developments at three analytical levels: the socio-technical regime, the niche of innovation and the socio-technical landscape (Geels 2011).

Socio-technical regime

The level of the socio-technical regime is the 'deep structure' which describes the stability of an existing socio-technical system (Geels 2004) and refers to the configuration of responsible institutions and the physical infrastructure for which they are responsible (Geels 2011, Liu and Jenses 2018); in the contest of urban water system the regime includes the water authorities and utilities, and all the infrastructures such as pipes, pumps, treatment plants, storage facilities, etc., which constitute the system itself (Liu and Jenses 2018). Socio-technical regimes are "dynamically stable" as they are characterized by lock-in. Innovation happens incrementally with slight amendments accruing into steady trajectories. These trajectories occur not only in technology, but also in cultural, political, scientific, market and industrial dimensions (Geels 2011). The regime operates according to its sanctioned discourse, which is checked by the cognitive, normative, and regulative conditions, or 'pillars,' sustaining the regime (Geels 2004, Liu and Jenses 2018). In the case of urban water systems and water management, the relation between the regime and the wider society is indicated as 'hydro-social contract' (Lundqvist & Turton, 2001), which represents per-

2. i.e. a theory that does not concern large and abstract entities such as "society" or "social system", but is aimed at investigating concrete phenomena (such as socio-technical transitions). MRT differs from the great theory, because it emphasizes the interactions between theory and empirical. MRT specifies the relationships between concepts in analytical models (Geels 2011).

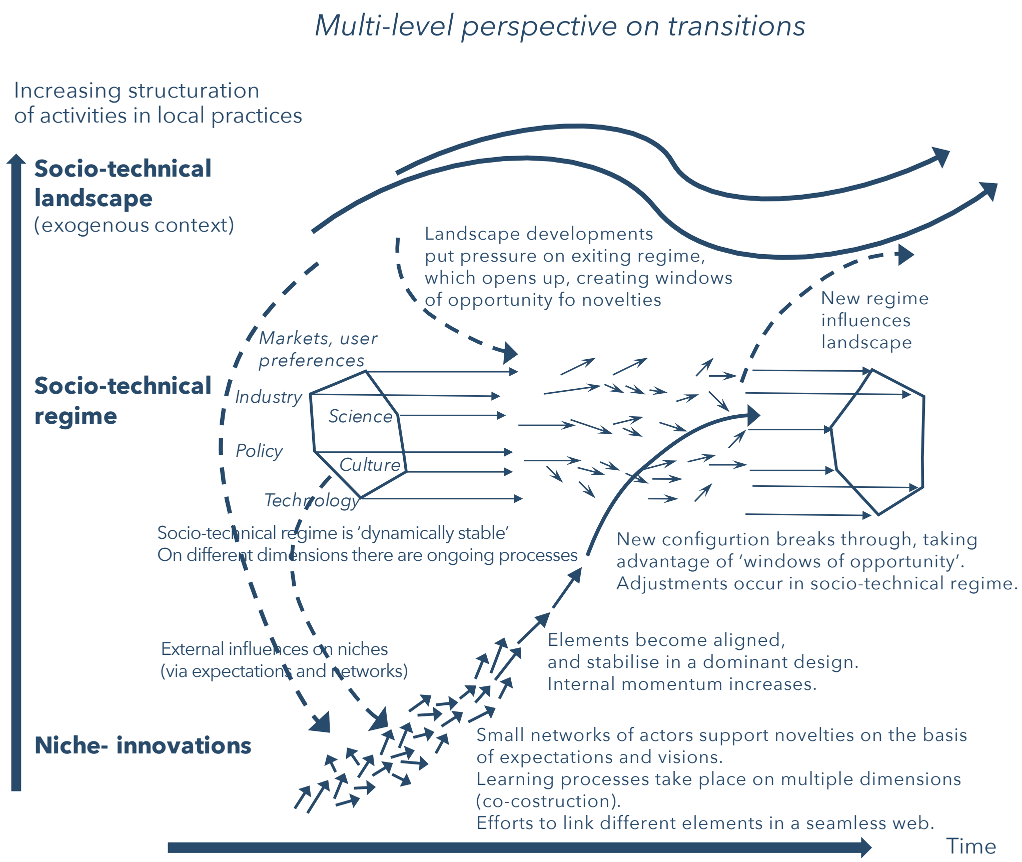


Fig.1. Scheme of the Multi-level perspective approach for socio-technical transitions, re-elaborated from that proposed by Geels (Geels 2004, Geels 2011).

vasive values and expectations regarding how water should be managed, and has typically been shaped throughout the history of the city (Liu and Jenses 2018).

Niches

Niches are defined by Geels as 'incubation rooms for radical innovation' or 'protected spaces' such as research centres, research and development laboratories, universities, funded demonstration projects, or small market niches in which operators have exceptional demands and are willing to support emerging innovations (Geels 2004, Geels 2011). Actors of the niches (such as entrepreneurs, start-ups, spinoffs) propose alternative approaches that suggest innovations to be adopted in the regime or even replace it, although embracing novelties is not easy as the existing regime is steadied by many lock-in mechanisms and because niche-innovations may have a mismatch

with existing regime dimensions (e.g. lack of appropriate infrastructure, regulations or consumer practices). Niches deliver the germs of systemic change and provide the opportunity to shape the social networks that support innovation; thus, they are critical for transitions. When expectations towards innovation become more defined and largely accepted, niches gain momentum "if the alignment of various learning processes results in a stable configuration ('dominant design'), and if networks become larger (especially the participation of powerful actors may convey legitimacy and resources to niche-innovations)" (Geels 2011, page 28).

Sociotechnical landscape

The sociotechnical landscape is the wider context. It does not refer to the landscape architecture, but rather (in MLP) to the wider exogenous environment and includes "the material aspect of society, e.g. the material and spatial arrangements of cities, factories, high- ways, and electricity infrastructures" (Geels 2004, page 913). Landscapes, as meant in the MLP, are outside the direct power of actors and cannot be modified at will. They represent the environmental, social-political, and economic pressures acting on the system; in the contest of urban water system, the landscape level pressures can be referred to climate change impacts, urbanization, and public requests for increased liveability.

Figure 1. represents a graphic illustration of how the three levels interact dynamically in the evolution of the socio-technical transition according to the MLP approach. Each transition is unique, but one can grasp dynamic patterns that arise from the interaction between processes at different levels:

a. Changes in the landscape can generate pressures on the regime (e.g. impacts generated by climate change on urban water systems);
b. Niche innovations enhance the internal momentum;
c. Negative externalities and effects on other systems (e.g. environmental impacts, health risks and safety concerns) can lead to pressure on the regime;
d. Destabilization of the regime generates 'windows of opportunity' for niche innovations. In this phase, a radical innovation may occur bringing about wider changes (e.g. in policies, infrastructures, user practices).
e. Innovations may enter in competition with the established system and may ultimately replace it developing a new regime with different actors (Geels 2004, Geels 2011).

Eventually, the new regime may also influence the landscape (e.g. through the reduction of greenhouse gases aimed at mitigating climate change).
MLP is not based on simple principles of causes and effects in transitions, but rather analyzes processes in multiple dimensions at different levels that interact and reinforce each other according to a 'circular casualty'.
As suggested by Smith, Voß and Grin, the MLP can be developed focusing on the spatial aspects of transitions, i.e. how "the functional socio-technical spaces of niche, regime and landscape relate to other dimensions of space, such as territorial, administrative and communicative spaces" (Smith et al. 2010 page 446). Thus, it can be useful for identifying how the path towards progressive stages of sustainability in urban water management takes the form of projects and interventions that necessarily lead to a change in the city's physical space.

2.1.2 Transition framework towards water sensitive cities

The design for resilience to the impacts of climate change and population growth, in particular as regards the sustainable management of water resources and the protection of water environments is recognized as a critical challenge for urban communities (Wong and Brown 2009). An internationally growing interest on the transition towards a more *Sustainable Urban Water Management* (SUWM – Wong 2006, Wong and Brown 2009) is often counterbalanced by urban water strategies that lack a clear vision about the objectives and attributes of a sustainable water city (Brown, Keath and Wong 2009).
The description of the level of transformation towards resilience can be based on the structure formulated by R.R. Brown in the *Urban Water Management Transition Framework* (UWMTF) (Brown et al. 2009, Brown et al. 2007, Brown et al. 2013) intended to overcome barriers to progress through the proposal of a benchmarking tool or heuristic device for informing the development of long-term policy for SUWM (Brown et al. 2009). Based on research developed on Australian cities, the UWMTF seeks to propose potential future hydro-social contracts underpinned by sustainable principles. The 'Regime' as described in the MLP approach is controlled by three 'pillars' that collectively shape patterns of practice: the *Cognitive* condition represents the dominant knowledge, thinking and skills (which are, as an example, challenged by the concept of SUWM that proposes a change in cognition in the water sector); the *Normative* pillar exemplifies the values and leadership (challenged by the growing focus on environ-

Urban water management transitions framework

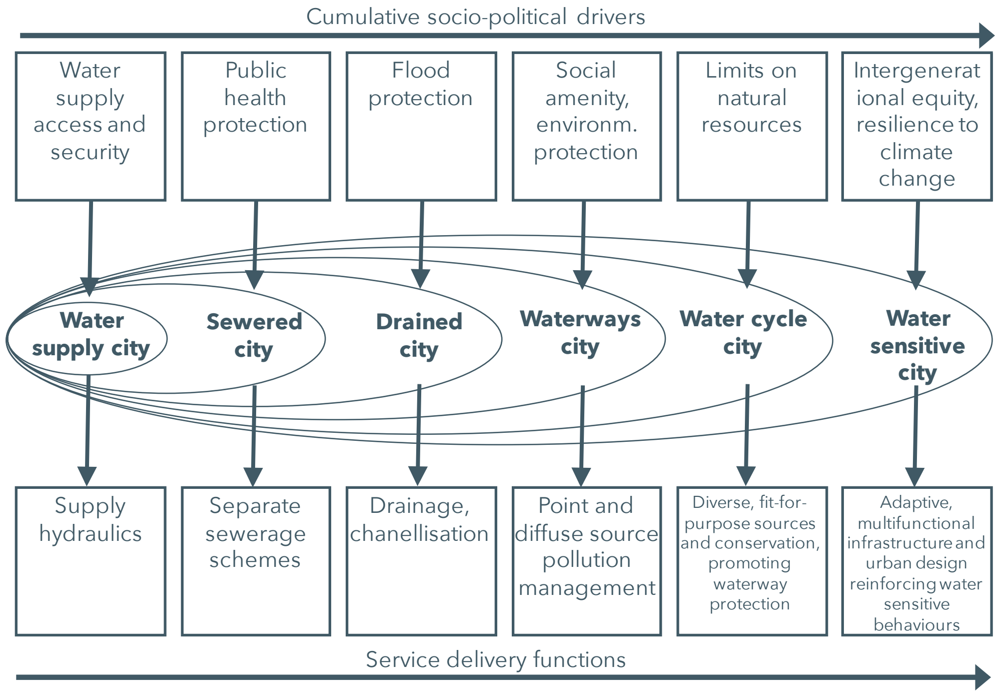


Fig.2. Scheme of the Urban Water Management Transition Framework, re-elaborated from that proposed by Brown (Brown, Keath and Wong 2009, Wong and Brown 2009).

mental protection); the *Regulative* pillar, which stands for administration, rules and systems designed to protect the dominant values (normative) and thinking (cognitive) (Brown et al. 2009, Scott 1995). In order to achieve a progress in transition towards SUWM, shifts in the practice within each of the three pillars are necessary (Brown et al. 2009, Liu and Jensen 2018).

Fig.2. is a graphic representation of the UWMTF. The 'Cumulative Socio-Political Drivers' reflect shifts in the normative and regulative dimensions of the hydro-social contract and the 'Service Delivery Functions' represent the cognitive response. Brown identifies six stages that describe the degree of transition and progress of cities from the most primitive stage to the most advanced one.
The *Water Supply City* describes the city providing safe and secure water supplies for a growing population, thus building the urban hydraulic system.
The *Sewered City* emerges when epidemic diseases spread through the contamination of drinking water by pathogens deriving from wastes, sewage and industrial effluent. It develops during the industrial revolution, when

the hydro-social contract promises to guarantee the protection of public health to a growing urban population through the construction of a sewage system that directs waste water towards a waterway environment (or in some cases towards on-site septic systems, when the infrastructure has a prohibitive cost). The new regulative regime often involves the creation of boards responsible for water supply and sewer systems, and levies are added to property taxes.
The *Drained city* emerges after the Second-World War with the rapid expansion of cities and the consequences on the regimentation of water and flooding, the diffusion of private cars that allow people to live far from the centre, and the increased government investments in infrastructure and welfare. The new discipline of urban hydrology develops during the 1960s focusing on evolving techniques and models that enables the rapid and efficient conveyance of storm water out of cities, to receiving waterway environments. Several waterways are piped and located underground, and river systems channelized to consent for more urban development. The hydro-social contract implicitly promises the efficient conveyance of storm water to waterway environments in order to prevent flood risks and enable rapid urban expansion. Waterways are normally not socially valued as urban landscapes and they are often used as waste dumping grounds.
The *Waterways city* develops when the growth of environmental movements and the raising concerns about increasingly degraded and polluted waterways challenge the service delivery functions adopted under the previous city states. The cities described above witness the normative perspective in which economic priorities come before those of a benign environment. In the Waterways city state, water starts to be a part of the planning functions also for visual and recreational features; in order to reduce pollution gathered in waterways, new measures and regulations are adopted to control environmental discharges from treatment plants and industrial processes; septic tanks are replaced with centralised sewage systems; new stakeholders, like communities and environmental groups play an active role in changing functions and responsibilities and often creating tensions and pushing towards the adoption of new practices involving environmental protection.
The *Water Cycle City* tries to respond to the awareness of the limitation of traditional water supply resources, to the growth of cities and urban population, to the understanding of the limits that waterways have as means to absorb pollution, and to the widely growing normative acceptance of the need for sustainability. Water resources are touching the boundaries of sustainable exploitation, thus, researchers and practitioners look at the whole water cycle approach and, being involved in interdisciplinary, multi-stakeholder learning, search for new flexible solutions (for example for water supply from rainwater, storm water, sewage, seawater). At this city sate, some visions propose water supply from alternative sources through widespread and decentralized technologies, supporting new forms of co-management with the community and the private sector.
The *Water Sensitive City* is a vision of a city to aim for, cause at the moment no urban area in the world has reached this stage, although the concept attracts the attention of scientists and practitioners interested in figuring potential future sustainable water. The Water Sensitive City is sustainable, equal and resilient to climate change; its water services are delivered through adaptive, multifunctional infrastructure and urban design reinforcing water sensitive behaviours. The hydro-social contract would combine different normative values including, among others, environmental protection, security of supply and flood control, public safety and health, liveability and economic sustainability, and it would be adaptable and dynamic underpinning a flexible institutional regime (Brown et al. 2009).

Although the UWMTF was developed from research on Australian cities, it is proposed as a conceptual tool to analyse the development of urban water transition, and urban scale benchmarking of cities with different characteristics. It takes into account the temporal, ideological and technological contexts that cities cross in the path towards the sustainable management of water in urban areas and appears as a valid tool to compare the results of analyses carried out on different case studies, also for climatic field, organization and management structure, politics, decision-making, dimension and path (Brown, Keath and Wong 2009, Wong and Brown 2009).

2.2 Meso/micro level – scale of the interventions – analysis of implemented and /or planned projects

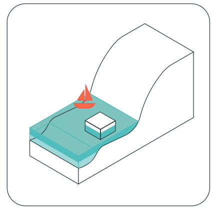
Adaptation policies and strategies are implemented through concrete spatial interventions at the district scale or single architectural project scale, i.e. at the meso/micro level. As far as the analysis at the scale of interventions is concerned, a general framework has been defined which contains the categories useful for the description of implemented or planned projects and is connected to the two dominant development strategies according the evolutionary point of view before mentioned: the shark and the rat. For 'adaptation projects' we can consider all the interventions aimed at facing an impact. While the analysis at the macro level is framed around theoretical transition concepts, at the meso/micro level the categories aimed at defining the projects are empirical and arise mainly from the observation

of the interventions themselves and from data collected.
The thematic classification of the interventions is divided into three families of characteristics that identify: the approach of the projects towards adaptation; the approach of the 'shark'(techno centric – grey infrastructure), of the 'rat' (eco centric and holistic – blue/green infrastructure) or a hybrid approach; the approach and action towards water. A fourth family of sub-categories describes the relationship of the intervention with the pre-existing elements on the site through actions of reuse/retrofit, addition and removal/subtraction.
Another group of elements is meant to give a partial qualitative overview of the project results defining the social, economic, environmental, ecological, and communication values with respect to the condition prior to the intervention (or at least the expected results in case of projects not yet implemented). Furthermore, considerations on the advantages, disadvantages of the interventions and relationship they establish with water are provided.

2.2.2 *Adaptation features: coping approach; incremental adaptation; transformational adaptation.*

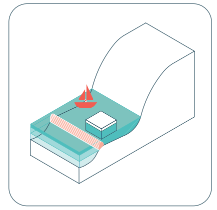
A first definition of the projects is based on the analysis of the adaptation approach (see chapter 1) that the projects themselves implement. In fact, each intervention witnesses an approach aimed at adaptation through which it is possible to identify a broader orientation in dealing with impacts and a consequent effectiveness of the intervention itself on a shorter or longer time horizon.
Three broad categories are distinguished as follows

- ***coping approach*** focused on solving the problem rather than addressing complex issues, thus handling with the emergency with a relatively quick and not extremely expensive solution;
- ***incremental adaptation*** when existing adaptation measures are incrementally improved and increased in efficiency and implemented in order to follow the requirements of vulnerability assessment and adaptation plans;
- ***transformational adaptation*** that promotes a change of approach towards the challenges, trying to provide new and innovative solutions with the aim of transforming problems in opportunities and support the path to a resilient and sustainable city. Transformational adaptation



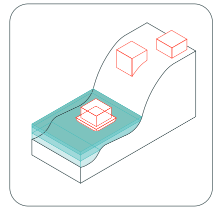
Coping

Responding to an unexpected tragic event and putting into practice existing adaptation measures and acquired knowledge aiming to solve the contingent problem.



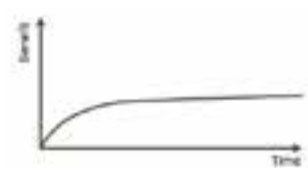
Incremental adaptation

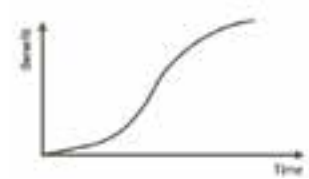
The existing adaptation measures are progressively improved, their efficiency is increased and they are implemented to follow the vulnerability assessment and adaptation plans. Benefits on a medium term.



Transformational adaptation

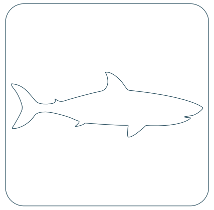
Approach that investigates and addresses the causes that can increase the impact of climate change. Aims to combine adaptation with other aspects of urban development in a long-term systemic perspective.





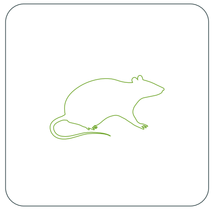
is a wider and systemic approach that investigates and deals with the causes, frequently linked to human actions, e.g. settlements set in risk-prone areas, inadequate building design or other human activities that may increase the impact of climate change. (EEA 2016).

'Coping' is mainly related to rapid response actions in the event of an hazards, rather than projects that derive from a planning path with respect to the risks and impacts, therefore it was not considered relevant for research purposes to consider in detail the interventions that are part of this category, but rather focus on the other two adaptation approaches, resulting from a wider vision.



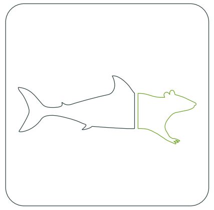
Techno-centric approach

- Grey infrastructure (GI)
- Function and performace



Holistic and Eco-centric approach

- Blue/Green Infrastructure (BGI)
- Nature as infrastructure
- Multiple benefits
- Harmonization between functioning, function, performance and spatial planning in urban areas
- multiple benefits



Hybrid approach

- Integration among the techno- centric and the holistic and eco-centric approach
- Projects using both nature based solutions and grey infrastructure

2.2.3 *Infrastructure features: shark - techno-centric approach; rat – eco-centric holistic approach; hybrid approach*

The second family of categories is connected to the development strategies according to the evolutionary point of view previously mentioned (see chapter 1) and distinguishes three types of approach towards the project, the territory and more generally towards the natural elements: the shark or techno-centric approach typical of *grey infrastructure* GI; the rat or eco-centric holistic approach of *blue-green infrastructure* BGI; the *hybrid approach* HI.

Shark - Techno-centric approach – grey infrastructure
The most techno-centric philosophy of the conventional approach typical of recent history, which involves the use of technical solutions, has often addressed urban water management (and not) through traditional systems or grey infrastructure (GI) with numerous environmental and economic consequences. GIs are designed for a function and respond to a performance. Like the shark, the GIs often guarantee good functionality in stable conditions, but are inadequate to face the climatic extremes. Moreover, in Western countries, often designed and built decades ago, the GIs have problems of obsolescence and difficult maintenance.

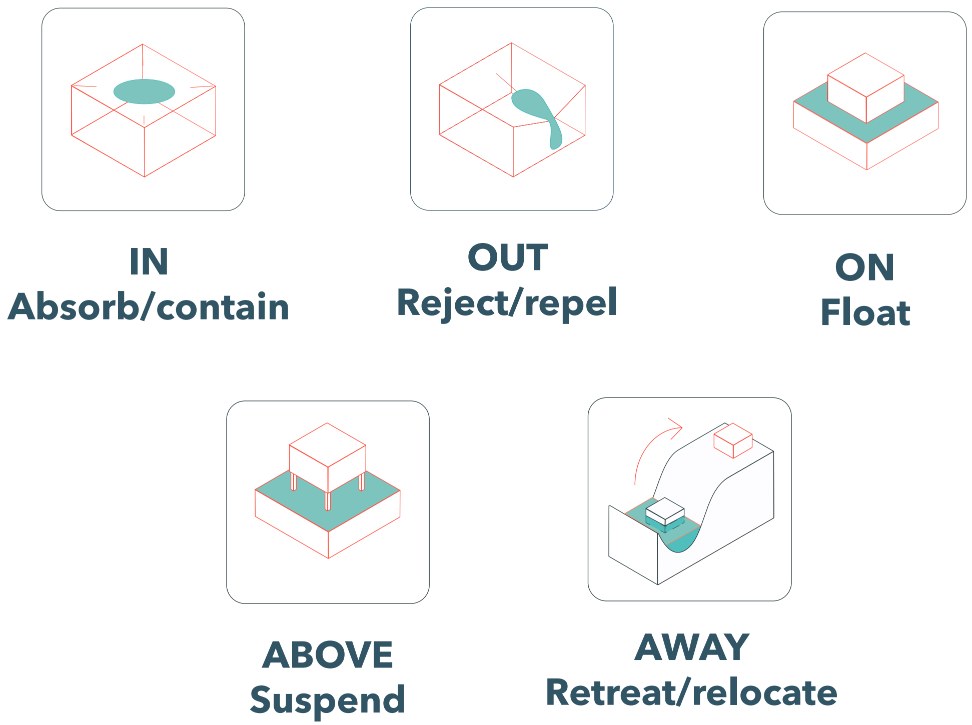
Rat - eco-centric holistic approach - blue-green infrastructure
The aptitude of the rat to adapt to different conditions, find different sources of subsistence and be resilient is a metaphor for the eco-centric and holistic approach to adaptation projects that takes the form of interventions that use 'nature as an infrastructure', i.e. BGIs. These propose a harmonization between functioning and function, performance and spatial planning, also ensuring multiple benefits for the community. Although some interventions actually propose natural-based solutions and not real BGIs (see chapter 1), this category includes all the projects that are considered to have an eco-centric and holistic approach.

Hybrid approach
Like a sort of in-between animal, half rat and half shark, this category describes projects that apply a middle attitude that implements both GIs and BGIs (or rather nature-based solutions). Some interventions seem to have the will to adopt innovations, but still in a weak way, thus implementing GIs with some devices or some parts of the project that take into consideration the impacts that the same can have on the environment or ecosystems present in the area.
It is relevant to note that some interventions require a hard (traditional) technical structure, however, it can be combined with solutions that guarantee, for example, the survival of ecosystems or at least limit its damage. An example are the dams, banks and walls on the coasts or on waterways often becoming inhabited thresholds, places for the community that incorporate different spaces and uses. Concrete and metal barriers are being replaced by increasingly naturalized levee, resulting from earth movements and soil modelling.

2.2.4 *Project relationship with water*

A further classification defines the interventions based on the spatial relationship the project establishes with water, and on the action towards water. The five features are:

In - absorb / contain
The interventions that consist of: absorbing and containing water in order to store, then purify and use it as drinking water or to water gardens; collecting it in order to return it to the disposal system at a later time, for example when the episodes of heavy rain have ended; decreasing the run-



off that causes pollution of the waterways and to filter it, are increasingly common. Water canalization, the extensive use of urban soil and impermeable pavement have depleted the underground water tables, creating hydrogeological imbalances and often causing subsidence. The use of draining surfaces and porous paving, increasingly in practice, contribute to the recharge of aquifers and to limit the need to dispose of surface water which, in case of extreme phenomena, can cause flooding, as happens in recent times in Italy. In many regions around the world climate change exacerbates the phenomena of extreme rainfall that alternate with periods of drought, therefore the collection and conservation of water becomes increasingly crucial.

Out - reject / repel

This type of intervention, which is traditionally recognized in the construction of embankments and dams, arises in opposition to water flows, blocks their course. This category also includes projects that channel water through pipes or beds of concrete waterways in order to dispose of it by transporting it as quickly as possible to the collection basins, rivers and seas. Although in the recent past it was the most common strategy

to defend against floods, today it represents an extreme case where it is not possible to intervene with other types of projects that favour a greater adaptation of the territory to the dynamics of water, rather than an action of resistance. The coastal and river margins are mainly the subject of this type of intervention through the construction of higher and higher walls to protect from the power of water, as it is happening in some villages of the Japanese coast following the tsunami of March 2011. However, in contemporary projects, these walls often aim to become inhabited thresholds, places of the community that incorporate different spaces and uses. Often barriers made of concrete and metal are being replaced by increasingly naturalized levees, result of earth movements and soil modelling.

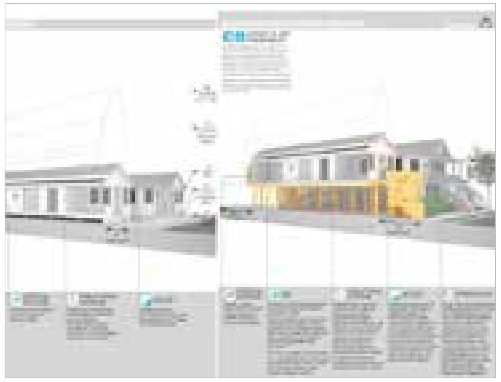
On - float

Some interventions are built on water, almost as if it were a new urban soil. Beside the interventions that are configured as real infrastructures related to water management, some projects aim rather to propose new models of living with water: houses, pavilions, neighbourhoods and cities floating, thus making adaptation a new lifestyle. In recent years living on water is an increasingly growing phenomenon. The poor availability and high costs of urban building land, the romantic ideal that small floating structures represent and the possibility of living in a nomadic and sustainable way, combined with the low construction, rental and management costs of the houseboats (compared to houses and apartments on land), has determined a rapid development of floating architecture. These constructions apparently do not belong to the type of infrastructure, although they are often technologically advanced facilities. The interventions relating to this category seem to oppose any water regimentation action, but rather to live with it.

Above - suspend

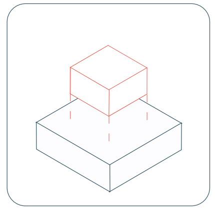
Some interventions involve raising the ground floor or at least the first living level above water elevation or the expected share of flooding, thus reducing the footprint on the ground. The stilt or suspended building type is common for example in traditional architecture in Cambodia (Fig. 3), but also in Queensland architecture in Australia (Fig. 4). Some contemporary projects take up this idea, such as Thomas Heatherwick's Pier55 in New York, U.S. (Fig. 5), or the plan 'Retrofitting Buildings for Flood Risk'[3] developed in 2014 by the Department of City Planning, City of New York,

3. Information about the New York's plan 'Retrofitting Buildings for Flood Risk' are available at the website: www1.nyc.gov/site/planning/plans/retrofitting-buildings/retrofitting-buildings.page



Top left fig.3. Kampong Pluk – Siem Reap Province, Cambodia; top right fig.4. Queenslander houses Source: https://www.abc.net.au/news/2019-01-22/the-unspoken-asian-influence-on-queenslander-houses/10692948; bottom left fig. 5. Pier55 – New York, USA – Thomas Heatherwick; bottom right fig.6. Source: The City of New York, and Department of city planning. 2014. "Coastal Climate Resiliency - Retrofitting Buildings for Flood Risk."

(Department of City Planning, City of New York 2014) where the building types are studied and retrofitting is proposed by lifting up the existing construction, leaving the ground floor 'free' to be used as a parking, but not inhabited space (Fig. 6). An example of a famous stilt house architecture is Ludwig Mies van der Rohe's Farnsworth House, built between 1945 and 1951. The house was built near a river at a level raised above the ground in order to avoid flooding in the event of overflows. The extreme events of recent years have, however, far exceeded the water levels expected at the time of the project, flooding the house. Stilt houses are often common in territories subject to seasonal or temporary flooding due to rivers overflow or hurricanes and storms. In these cases, buildings are based firmly on the urban land and not on water, therefore they do not suggest a new different lifestyle, but rather building types that are adapted to occasional flooding.



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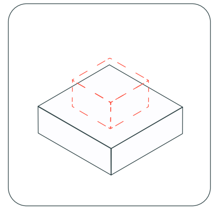
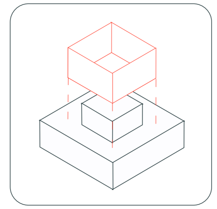


Remove



Retrofit/ reuse

Away - retreat / relocate

A fifth feature in the relationship with water corresponds to the retreat away from the territory where the impacts are more intense. This category of projects involves a real rethinking of the territory in a wider vision that often involves entire neighbourhoods, districts or regions. It implies abandoning the existing infrastructure and buildings to rebuild them elsewhere, away from the most serious hazards. An example of this attitude is the city of Kiruna in Sweden, whose growth has been linked to the existence of iron mines. The incessant mining activity caused a hydro-geological imbalance and consequent serious phenomena of subsidence; therefore, the sinking city will be progressively moved 3 km from the original location and rebuilt in a sustainable way. Most of the buildings will be demolished, except for some architecturally significant that will be relocated in the new city. As for the impacts related to water, a significant intervention is Blue Acres Floodplain Acquisitions Program, part of New Jersey's Green Acres Program[4], born after the Superstorm Sandy on October 29, 2012 that damaged or destroyed 346,000 homes and flooded a large portion of the state. Through the New Jersey Department of Environmental Protection Superstorm Sandy Blue Acres Buyout Program, the State will spend $300 million in federal disaster recovery funds to purchase flood- prone properties and give homeowners the option to sell Sandy-damaged homes at pre-storm value in flood-prone areas. The State will buy clusters of homes or whole neighbourhoods that were flooded in Superstorm Sandy or previous storms. These homes will be demolished, and the land will be permanently preserved as open space, accessible to the public, for recreation or conservation. The preserved land will serve as natural buffers against future storms and floods. The goal of the Blue Acres Program is to dramatically

4. Information about the New Jersey's Green Acres Program and the Blue Acres Floodplain Acquisitions available at the website: www.nj.gov/dep/greenacres/blue_flood_ac.html

reduce the risk of future catastrophic flood damage, and to help families to move out of harm's way.
Although the action of going away, retreating and relocating from the areas of higher risk is increasingly being considered, this feature is not highly represented in the analysis implemented.

2.2.5 Project relation with the pre- existence: reuse/retrofit; add; remove/ subtract.

The fourth family of features useful for the critical description of the projects is composed by three sub-categories that describe the action of the project towards the site status prior to execution.

Reuse / retrofit
This feature is meant to describe the interventions that relate or are combined to elements or existing buildings and reuse them through, for example, a change of function or through a restructuring and retrofitting aimed at modifying them so that they can guarantee performance or adjustment to the new project. Examples are projects that add an adaptation element to existing buildings, such as green roofs, water collection and filtration. Other examples are the raising of existing buildings or their retrofitting so that the ground floors are emptied, the installations (that are often in the basement) are moved on the roof, so that they can adapt in case of flooding.

Add
Many interventions are in addition to the existing structures or constructions on the site through an incremental increase in the elements aimed at adaptation, or through urban densification. Examples are the projects for the construction of new dams or embankments or sea walls, the interventions aimed at raising the ground in areas prone to flooding, those that introduce new structures or buildings with adaptation characteristics.

Remove / subtract
This subcategory refers to interventions that modify the site through removal or subtraction operations, for example through the demolition of buildings, infrastructures or existing elements. Removal is often intended to re-naturalize an urban environment, to eliminate elements obstructing

water flow such as the demolition of buildings in flood prone areas, the removal of bottlenecks and bridges, the reopening of covered underground rivers, the elimination of barriers and sea walls.

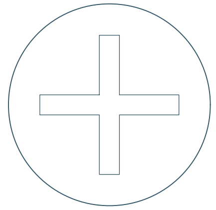
2.2.6 Project values

Further elements for the critical description of the projects are added to the categories explained above. They are intended to give a general and qualitative indication of the added value of the interventions compared to the previous situation. Those features are the result of the collection of inputs from the people interviewed, from data collected, from field observation, from impressions on the use of the adapted areas, but they are not based on quantitative data or key indicators as those were not available, therefore they are only meant to provide an additional level useful for defining the selected interventions. As a further analysis, the features refer to some qualitative elements that define the social, economic, environmental, ecological, and communication value of the projects. Furthermore, considerations on the advantages, disadvantages and the established relationship with water are added. Represented by the icons below, each characteristic is assigned a value from zero (low value) to four (high value).
A short list of elements taken into consideration for each feature is mentioned below. Through adaptation projects mapping, selection and description sheets, further specific details relating to the individual intervention will be provided.

Social value
This feature takes into consideration elements that improve the social liveability and cohesion of the community benefitting from the adaptation intervention: increased public areas; community building; meeting or gathering place; improved recreational facilities; educational environment; safety.

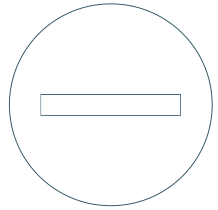
Ecological value
Ecological value in the proposed feature stands for the project's attention to the respect of the ecological balance in the area. The elements considered are: more green in the city; increased habitats for local species; improving the ecological network.

Economic value
Adaptation projects are often linked to urban regeneration and consequently have some repercussions on economic aspects of the area such as: increased property value; innovation and development; production and sales of own-grown products; stimulating local production.



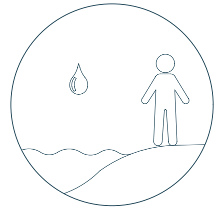
Advantages

- Multifunctional space
- Improved safety
- Improved quality of life
- Flexible solutions



Disadvantages

- Less attractive environment
- Non flexible solutions
- Impacts solved for a short/ medium term



Relationship with water

- Closer contact with water
- Strengthening the relationship of the city with water
- Increase in activities related with water
- Increased surface water
- Water recycling

Communicative value
As mentioned before, urban resilience and sustainability have often gained a positive aura that is also used in the promotion (tourism, politics, to attract investors) of cities, as well as having a crucial role in informing and making citizens aware of the risks related to impacts. Among the factors taken into account to describe the communicative value: raising awareness among citizens about climate change and human related impacts; city networks, media attention; lighthouse or pilot project.

Environmental value
At the environmental level, contributions that the interventions have on the neighbourhood and the surrounding area, are taken into consideration. Adaptation projects can have positive consequences such as: more attractive residential/ working environment; increased quality of air and water.

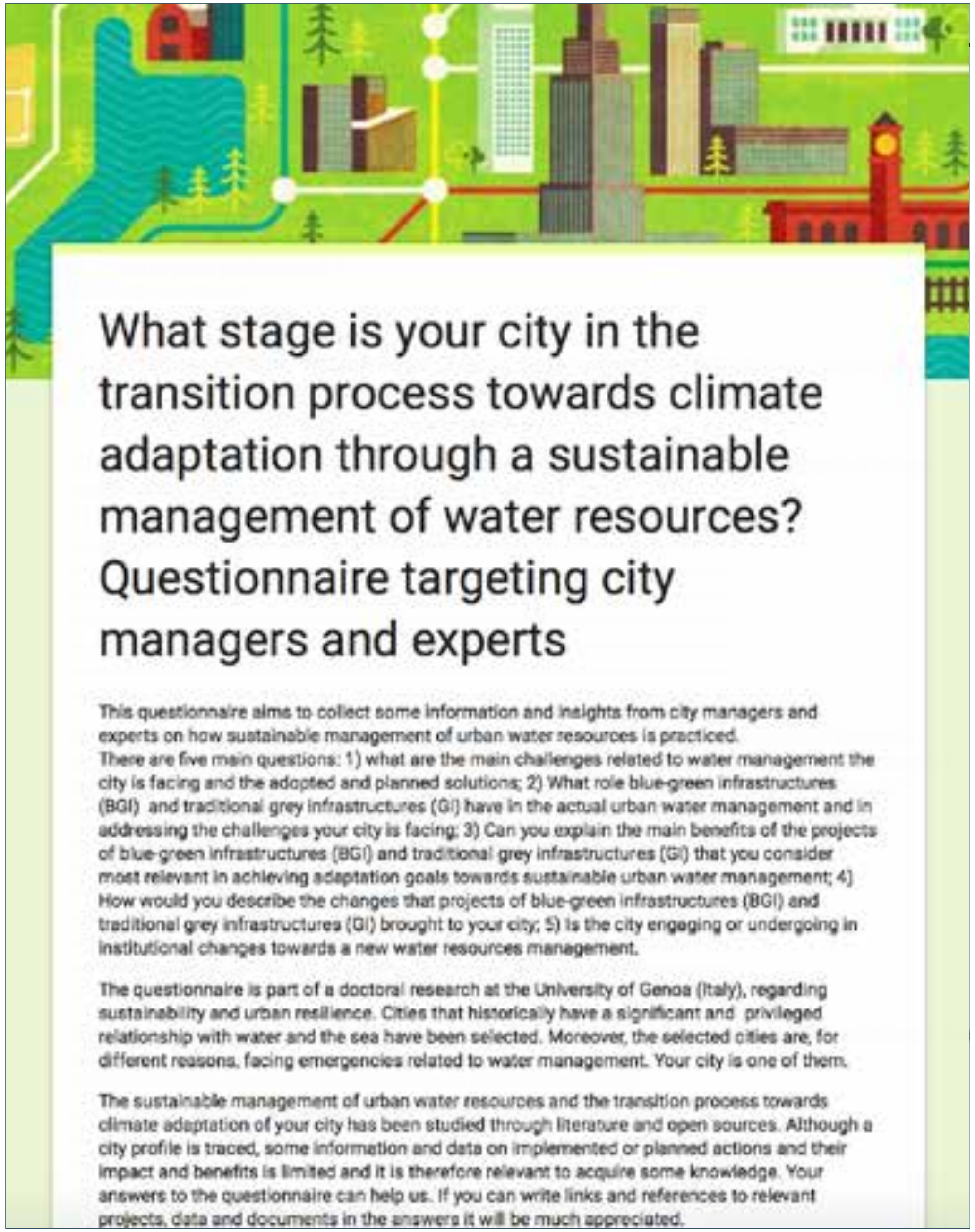
Advantages
Further characteristics concern the advantages that an adaptation project can offer. Among these, for example: multifunctional space; improved safety; improved quality of life; flexible solutions.

Disadvantages
Alongside the advantages, disadvantages can sometimes be encountered, for example when a project modifies the possibility of benefiting from water, through structures that create a barrier. Among the disadvantages: less attractive environment; non flexible solutions; impacts solved for a short or medium term (not on a long-term perspective).

Relationship with water
Depending on the type of intervention, adaptation projects can substantially change the relationship that users (citizens) have with water. The elements taken into consideration to describe this feature are: closer contact with water; strengthening the relationship of the city with water; increase in activities related with water; increased surface water; water recycling.

2.3 Data collection

The investigation process is based on complementary methods used in each context. The selected cities were visited, trying to make the most of the possibilities offered by the context in terms of accessibility of spaces and data, and availability of local entities for meetings.
Public officials of city administrations have not always shown willingness to provide documents and data, albeit public ones, and sometimes difficulties have been encountered due to the language of documents (Dutch). Data are collected on a case-based data collection plan aimed at identifying for each research case the essential documents and contributions useful to understand the transition path and the interventions carried out although homogeneity and coherence of the collected materials has been planned. Data are collected from open sources, including the case cities' official websites, published plans, documents, articles and reports.
At the macro level, particular attention is paid to collecting materials related to strategic planning for a sustainable and/or resilient city that involves the city itself, the whole metropolitan area or large parts of it. Each city internal organisation with reference to water system, sustainability and resilience is considered. Water impacts and in general the water system (water supply, drinking water, waste water disposal, etc.), related problems and projects aimed at solving them are taken into consideration. Moreover, historical maps, plans, pictures and documents are collected so as to clarify the historical relationship of the city with water resources and impacts and the current path towards adaptation goals.
At the meso/micro level the analysis develops through the mapping and selection of adaptation interventions, data collection on each project, where


What stage is your city in the transition process towards climate adaptation through a sustainable management of water resources? Questionnaire targeting city managers and experts

This questionnaire aims to collect some information and insights from city managers and experts on how sustainable management of urban water resources is practiced.
There are five main questions: 1) what are the main challenges related to water management the city is facing and the adopted and planned solutions; 2) What role blue-green infrastructures (BGI) and traditional grey infrastructures (GI) have in the actual urban water management and in addressing the challenges your city is facing; 3) Can you explain the main benefits of the projects of blue-green infrastructures (BGI) and traditional grey infrastructures (GI) that you consider most relevant in achieving adaptation goals towards sustainable urban water management; 4) How would you describe the changes that projects of blue-green infrastructures (BGI) and traditional grey infrastructures (GI) brought to your city; 5) Is the city engaging or undergoing in institutional changes towards a new water resources management.

The questionnaire is part of a doctoral research at the University of Genoa (Italy), regarding sustainability and urban resilience. Cities that historically have a significant and privileged relationship with water and the sea have been selected. Moreover, the selected cities are, for different reasons, facing emergencies related to water management. Your city is one of them.

The sustainable management of urban water resources and the transition process towards climate adaptation of your city has been studied through literature and open sources. Although a city profile is traced, some information and data on implemented or planned actions and their impact and benefits is limited and it is therefore relevant to acquire some knowledge. Your answers to the questionnaire can help us. If you can write links and references to relevant projects, data and documents in the answers it will be much appreciated.

Fig.7. Header of the online Questionnaire "What stage is your city in the transition process towards climate adaptation through a sustainable management of water resources?" The complete questionnaire is available in the Annexes of the thesis.

possible dialogue with the designers or with the administration officials who followed their development, site visits. Participation at public meetings, workshops and presentations gave the opportunity to get in contact with public officials and experts, and with citizens and activists as well. Data collection also has been giving importance to stories and interpretations provided by books, magazines, people, scientific articles and in general to the relationship with the citizens, to their sentiment and concerns expressed through associations and their interventions at public meetings and discussions on the plans and/ or projects proposed by city authorities.

2.3.1 Definition and draw up of an online questionnaire

A city profile on the sustainable management of urban water resources and their transition process towards climate adaptation of each selected city is traced, based on the study of literature and open sources. Nonetheless, some information and data on implemented or planned actions and their impact and benefits is limited and it is therefore relevant to acquire some knowledge. In order to validate and have updated and more in-depth data an online a questionnaire is conducted with the aim of collecting some information and insights from city managers and experts on how sustainable management of urban water resources is practiced. The questionnaire was developed taking inspiration from other researches with similar aims and in particular on the one implemented by Liu and Jensen (Liu and Jenses 2018). In Fig. 7 the header of the questionnaire entitled "What stage is your city in the transition process towards climate adaptation through a sustainable management of water resources?" administered online via Google form, with the introductory explanation for those who fill it out; in the Appendix of the thesis you will find the complete text and questions. The questionnaire is divided into three sections focused on: sustainable city through urban water management; the role of traditional grey infrastructures (GI) and blue-green infrastructures (BGI) in urban design and urban water management; institutional and organizational changes underway towards a new way of managing water resources in the city. Some key issues are included: the main challenges the city is facing; the role of the techno-centric and holistic eco-centric approaches; which projects are more innovative and why; how they changed the physical space; what challenges and goals are pursued.
Questionnaires were followed by interviews, and emails when clarification was needed. In total, eight among city managers and experts responded to the questionnaire and provided follow-up information. During the operational

phase of the analysis, this method was found not to be the most effective for some reasons: the breadth of the topics covered; the interpretation of the specific terminology is not always unique depending on the city and Country to which the target answering belonged; some questions were sometimes not immediately understandable in details, depending on the specialization of the people who answered. Thus, a further step was defined, firstly through exchanges of e-mails, phone calls and dialogues or interviews to clarify some points, secondly through an increase and a more in-depth development of the semi-structured interviews, already foreseen in the planning phase of the analysis.

2.3.2 Semi-structured interviews

The semi-structured interviews proved to be a much more effective method, with respect to the questionnaire, for gathering information and deepening some aspects of the urban adaptation path both from the point of view of the strategies planned at the macro level and from that of the interventions implemented or planned at the meso/micro level. A direct contact rather than mediated by the online questions placed the interviewees in a better attitude to express their opinion and provide information on the topics covered.
The interviews were administered starting from a similar plot outline, but then they were gradually articulated based on the interviewee's specialization, their interests and the importance that was given to some aspects during the dialogue. Starting from a fixed number of similar questions, depending on the availability and involvement of the interviewee, other open questions were asked in variable numbers.
A total of twelve interviews were conducted with public officials from different offices, designers and experts from the scientific and academic world. Some non-formal dialogues and exchanges of views in addition to the interviews provided valuable information and insights. Although not all relevant divisions (city planning, green space management and water management, resilience offices) directly provided responses, it should be noted that the responding persons were selected through internal dialogues in each city, in this way representing a joint view.
The semi-structured interview method allowed some crucial aspects to emerge, depending on the interviewee, talking about broader discourses on the path towards sustainability and urban resilience, or focusing on some specific aspects of the urban transformation process or on specific interventions related to adaptation. In addition, highlights and hints on particular projects

were provided that were useful for the analysis at the meso/micro level, for mapping and project selection.
Furthermore, very significant contributions arose for the definition and re-evaluation of the family of characteristics indicated as 'project values' such as inputs directly from the interviewees about core elements of the projects results in social, economic, environmental, ecological aspects; in the relationship with water; in the advantages and disadvantages of the intervention.

2.3.3 Sites visits

Another key element for the analysis was the possibility of spending time in the cities selected as research cases, because it allowed to personally verify the relationship of the urban area and of some specific sites with the water element, as well as allowing to check and evaluate all the elements and data collected through the methods described above. In addition, observation and dialogue with users and designers (when possible), allowed highlighting some elements not directly legible through the available data and suggestions for the drafting of the 'project values'.
Moreover, concerning the analysis at the meso/micro level, site visits allowed to collect specific data, also through observation and photographs, useful for projects selection and for drafting of the adaptation projects sheets.

2.3.4 Mapping and selecting interventions

In some cases, as previously mentioned, the aura of urban sustainability and resilience are used as advertising tools for the city itself, its tourism or its politicians that promote themselves through the actions implemented by the local administration. This involves, at times, considerable emphasis on adaptation interventions that often do not match the value communicated. Mapping of the interventions is performed in order to define a list of projects actually implemented or planned in the near future with adaptation objectives. Among the projects mapped in the research cases, a selection of some projects to be studied in greater detail is made. The selection took into account the approach and the proposed action and infrastructure aimed to adapt, the relationship of the project with water as well as some elements such as projects relevance suggested through the interviews and questionnaires, planning documents and cities' websites. Moreover, the value given to each project for communication purposes, the effects of the projects on the territory, the proposed innovation which, in some cases, may suggest imitation or the adoption of similar methods was considered as well.

Most of the selected interventions concern projects of public spaces or in any case accessible to the public, although some private initiative projects have been chosen as they present an innovative approach, sometimes a result of 'Niche-interventions' capable of influencing a wider public, therefore referable to the innovation niches presented previously.

2.3.5 City profiles and projects fact sheets

The analysis at the macro-level – scale of the strategic planning – analysis of the adaptation process, takes into consideration some key data of each research case which includes some physical characteristics, the water system, the impacts and challenges related to water management as well as the 'historical' production of the city's relationship with water. Through the MLP approach the urban transition path is defined in a clearer way by building a city profile that also describes the status reached within UWMTF. A sort of comparative matrix between the case studies enables to compare key issues, taking into consideration the following comparative elements: current UWM challenges ('landscape' pressure); goals of UWM (transition goal); the role of BGI in UWM (regime-led niche); scale of implementation and further strategies (transition management); barriers for BGI implementation (transition management); status of SUWM transition; prevailing adaptation approach; prevailing approach towards water.
At the meso/micro level – scale of the interventions – analysis of implemented and/or planned projects, the selected ones are described through project fact sheets aimed at providing a critical reading of the interventions. A more or less detailed fact sheet is dedicated to each selected project, according to the relevance of the project itself (for example, the communicative value that was assigned to the intervention, its innovative strength, the results and effects on the site and the neighbourhood). The sheets contain the identification of the categories to which each project belong and the salient features as indicated in paragraph 2.2, the identification of the planimetric position within the urban area, aerial photos of the site as it is and as it was previously (where possible), as well as photographs, project description and, in some cases, axonometric cross section or sections useful to describe the role of the project in addressing the emergency related to water impacts.
Through the adaptation project fact sheets, the aim is to provide an overview potentially expandable of projects and strategies. This way, the uniqueness of each individual context is useful not only for building critical images of the specific place but for returning the complexity of the contemporary city.
In the end, a comparison between the cities' profiles and the projects and general reflections on the adaptation paths is provided.

3 Application to research cases

The research intends to analyse two cities that historically have a significant and privileged relationship with water and the sea. Once selected, the analysis proposes to apply: the MLP approach for socio-technical transitions at the macro level – scale of the strategic planning, in order to investigate the adaptation process and, through the UWTF, the urban transition path towards a water sensitive city; at the meso/micro level – scale of the interventions, the study of implemented and/or planned projects carried out and foreseen and their critical reading through the categories identified in chapter 2, and through the drafting of projects fact sheets. The results of the analyses will then be compared according to some key elements useful for drawing considerations and reflections.

3.1 Selection of research cases Rotterdam and Miami

Potential case cities were listed from open sources, recommendations form experts and personal networks. The selection has privileged urban areas that are part of cities international networks aimed at enhancing resilience, currently facing emergencies related to water impacts, and who have developed a consolidated relationship with water throughout their history. The choice was aimed at cities with different climatic and geographic characteristics, in order to provide a wide range of impacts and proposed solutions. Moreover, selection criteria were also urgency and credibility on sustainability and urban water management.

The case study cities are selected taking into account some crucial parameters i.e. first of all the accessibility to the urban area and to data, projects, stakeholders and policymakers; the clear engagement of the city in going through a transition path to deal with CC, energy challenges and socio-economic issues; the capability of being an example for other cities in facing CC challenges; the involvement in international networks on sustainable urban development. Two cities that are part of the '100 Resilient Cities Program' (100RC) network, a non-profit organization set up by the Rockefeller Foundation with the mission of helping cities around the world to respond adequately to the economic, social and physical challenges of the 21st century, are chosen. The urban areas of Miami and Rotterdam are selected as research cases. Historically, they both have a significant and privileged relationship with water and the sea. Urban adaptation, in the cities of Rotterdam and Miami, is closely linked to water management and the water-related impacts of climate change, since water is a crucial element in the birth and development of these cities. For different reasons, they face emergencies related to the management of water resources and have therefore embarked on the path towards urban adaptation. Both are among the top fifteen on the list of cities in terms of resources exposed to coastal flooding in in the time horizon of 2070 (Nicholls et al. 2007). Another relevant element for the selection of cities was the availability of data and the possibility of spending research periods on the spot, through a research agreement with the Florida International University (FIU) and the Delft University of Technology (TU Delft).

Miami and Rotterdam are both engaged in a policy-development process on long-term adaptation to flood risk, although flood hazards are expected from different sources. They both adopt flood risk management approaches, with cultural differences, for example differences in risk perception and distribution of responsibilities between the public and private sector. Moreover, the selected cities have different regulatory systems, planning models, urban development, thus a comparison between the two metropolitan areas and their adaptation approaches may bring interesting and useful results.

In the US flood risk is mainly approached focusing on disaster management (adaptation, recovery and relief programmes) rather than on disaster avoidance and prevention, as it is in the Netherlands. Another difference between the two urban areas is related to the urban planning approach. In the Netherlands it is publicly managed and grounded on large-scale transformations and complete (re)development projects in which public and private stakeholders are involved and contribute (although recently a bottom-up urban development is more common). In the US urban development is more bottom-up, private sector-oriented and regulated by building codes and zoning.

The research cases represent a different geographic distribution as well as a difference in water management problems, thus constituting a range of possibility of intervention and management that can provide useful descriptive, explanatory and predictive indications of diagnosis and analysis to assess which strategic action initiatives adapt better to the current conditions of the system.